THE PRACTICAL MAGAZINE

NEW SERIES.—No. 26. VOL. 7, 1877.

SIR JOHN BROWN, SHEFFIELD.

IRON plates which are now essential in naval construction and defence, confer a distinction on the ancient municipality that almost rivals its ancient renown for cutlery: and, indeed, the remarkable increase which has taken place in the development of manufacture in Sheffield, is confessedly attributable to the establishment of new trades quite as much as to the augmentation of the old. Iron plates is one of these modern acquisitions, and the pratical monopoly in that department of the metal trade obtained by the Hallamshire Capital is ascribed to the energy of John Brown, who, seeing in the future an enormous probable consumption, went vigorously to work in a manner that would distance all competitors. Since that beginning many have followed; and the town has the practical monopoly.

It is important to distinguish the especial character of Mr. Brown's distinction. In writing our notices of Faraday, Wheatstone, Bessemer, and John Dalton, we have had to do with inventors—creators—so to speak, men who have by dint of mental and experimental toil made new worlds of human

industry and even more than that, thrown open vistas into regions, equally grand and profitable for others to explore. Here we have to consider the career of a manufacturer who availed himself of the discoveries of others and applied them on a grand scale to the immense advantage of the world and his own enrichment.

On the occasion of his first acceptance of the mayoralty of his native borough in 1861 Mr Brown avowed his purpose "to bear in mind during his year of office the maxim instilled in his mind when a boy in the Sunday school, always to endeavour to do my duty in that state of life in which it should please God to place me." And in thanking the council said, "I thank you sincerely and cordially for the honour you have conferred, not upon John Brown, but upon the course that John Brown has thought well to pursue throughout his lifetime, for it is in that light that I regard the expression of the approbation of this influential body."

One is glad to recognise the oft-repeated tribute to the freedom of our institutions uttered by successful men. It is no rarity: it is really the average: they win their glory from the easy and imperceptible gradations of life and its operations, and owe nothing to the intolerable anecdotes of men who, being introduced into a house, resolve to be masters thereof; such persons are simply scheming thieves. The good man pursues his way, and if blest with physical energy and a true heart, his life under ordinary circumstances will lead straightway to fortune. Mr. Brown is not ashamed, now that knighthood has wreathed his head, to say that he has shouldered his bag of tools and gone to work "like other men," and no sentiment of envy could come between his blessing and those who take their lot and do their best; nor does he ever cease to remember that amid the chances and changes of this mortal life, he is at once an example and a steward. An example in his career, and its success; a steward in helping others. We all have known the fickleness of fortune, and the good prosperous man never forgets either his history or obligations. If he did, surely all would wish those lofty wings were clipped and the ancient rebukes repeated. But the duties of kindness, help, and gratitude are always prominently observed in the great Northern towns and cities; and in that observance is their everlasting strength.

Born in 1816, so say Debrett and Dod, at Sheffield, the son of the late Samuel and Ann Brown, he gathered such knowledge as came in the way of an intelligent lad, and we are not so sure whether that can be regarded otherwise than the best way; he laboured in his "calling" most assiduously, and this working faculty enabled him to commence an independent career in 1844 by taking some small premises then vacant at Furneval Street, Sheffield, in which he did, as many others, give himself to the working of cast steel. Sheffield abounded with small masters. It is, as we have said, in the notice of Mr. Mark Firth, a usual occurrence of the most ancient date; and John Brown took leave to add his name to the list. *He would have cast steel.* Much of tradition and much of speculation hung about this particular production. The good gentleman living out west of the town at Acworth some hundred years before had left a mark,—which, by the way, our stupid hero-worship fashion is disposed to idolize,—that merely pointed towards cast-steel as the future of Sheffield, and did nothing beyond; bits of steel to make surgeon's blades and choice pocket and huntsman's knives were by him produced in rich perfection, and his secret contained the unknown, but there was no market; nobody wanted it in quantity; nobody cared to pay for quality; the difference between the imported and the native remained great; but as the native could not find an outflow, what was the use of his invention just then? But Hunstone is dear to every Sheffield man. His name is sacred there. Brown as a boy and a young man had known all these Hallamshire traditions, and his enthusiastic nature remembered them to some purpose. He set to work with astonishing energy, which he maintained with marvellous perseverance. The works soon became the focus of a thriving trade, and his repute grew rapidly. No sooner were the details of his cast steel business put in order than he added another branch, or rather specialty, by entering into the spring manufacture, in which he acquired a large business by the invention of a conical spring for railways. It was evident that more space must be obtained if the orders in hand and in prospect were to be executed in a satisfactory manner and the trade acquired be retained, and accordingly, having the opportunity of securing the newly erected works of Armitage, Frankish, and Baker, in Saville Square, adjoining the Midland Railway, of 3½ acres in extent, he removed thither. Here he introduced into Sheffield in 1855 the conversion of bar iron into steel, and added to his catalogue the celebrated Atlas boiler plates for which he obtained the government orders in the competitive strife by out-running his elder rivals, the Lowmoor and the Bowling companies. The works grew until they included 21 acres of land, which is almost entirely covered with buildings constructed for the employment of vast, complicated, costly, and powerful machinery, which very machinery has been created on the premises. It is scarcely necessary to say that these works, whilst a splendid manifestation of his genius, are regarded as a model and a teaching to all future machinists, by their fitness of design and thorough completeness.

The invention known by the name of the Bessemer process must be credited with the immense and sudden expansion of the Atlas Works. The early experiments had been made in London, and created no particular sensation, and even when the inventor read his famous paper at Cheltenham in 1856, he only provoked a controversy that enlisted the Birmingham manufacturers in a course of opposition and the utterance of words that had the appearance of springing from jealousy and ending in unreasoning prejudice. The patent was taken out, and the first license to use it offered to Messrs Galloway of Manchester. Those gentlemen had much regular business, and did not proceed with the development of the new mode. Mr. Bessemer determined on erecting works in Sheffield, and offered to his Manchester friends a share, as they had been his first and at that time the only licensee. Accordingly, five combined in the venture, and the Bessemer Steel Works at Sheffield were erected and still continue. Mr. Brown heard of these proceedings, and through a mutual friend was invited to inspect the novel operation of converting not bar-iron but iron-ore into cast steel. John Brown had taken high ground, avowed his determination to set up works, regardless of cost and size, in order to crush by competition the "young stranger," who had invaded Hallamshire, but he soon found that if bar-iron was given to him he would be a loser in such rivalry. His cast steel was then fetching £70, a ton and Bessemer also were selling theirs at £60. He learned that £50, £40, £30, and £20, could make the new invention remunerative, and instead of shaping his alterations on the old ideas, he took out a license and enlarged his works for the purpose of working the Bessemer process. His energy and confidence had a splendid reward, for he was able to secure very large profits, and take up any orders in the market, in spite of all competitors, who still remained incredulous and kept aloof from the new enterprise. His fortune was made by the abandonment of the old, and adopting with all his might the new discovery. We can have some idea of the kind of success that followed from the fact, that although he had carried on life in a liberal and freehanded manner, the company formed to take up his plant and contract at the period of his retirement, gave in money and debentures a million of money, besides securing five years' service from the vendor in his managerial capacity. The 21 acres of ground, and what grew to be 4000 artizans, made the iron trade of Sheffield in armour-plates, ordnance forgeings, shot, railway-bars, steel-springs, buffers, axles, tires, and all other items in railway and naval ordnance supplies. Soon after, Messrs. Firths and Messrs. Cammell followed suit and an honourable rivalry of a pleasant character has gone on ever since, between these distinguished firms, all of whom know well what Bessemer has been the means of revealing to their prosperity and that of their town.

These great houses have their specialty, and John Brown's was the manufacture of armour plates for covering ships and forts, and making them invulnerable to artillery. The Crimean war may be said to have formed an epoch in military and naval affairs; indeed, out of it came revelations of all kinds, and none very pleasing. Circumlocution went to the wall. Long peace had deprived nations of practical experience: and while improvements of every kind, and inventions of the most diverse description multiplied, and the work of testing, adopting, and rejecting, went on as usual, with, it must be added, the usual dissatisfaction, the rude operations of war had not intervened with its terrible teachings and siftings for forty years. Iron steam vessels had been made for some time, but notwithstanding the facilities they afforded for rapid transit of troops and stores, and the ease with which they could be manœuvred, the cannon ball struck them with fatal effect, and men-of-war ships were compulsorily made of the old material. It is said that the late Emperor of the French suggested the combination of iron and wood as a perfect repellant: whether that were so or not, the idea soon found friends who eagerly seized upon and adopted it. Forts and ships in all directions assumed their metallic clothing, and a trade sprang up as if by magic. Armstrong and Whitworth were running a race in the manufacture of guns, and something vigorous had to be done, or no ship of war could be kept afloat. This was in 1858, just at the time we have referred to, and the fame of the Atlas Works brought him the applications of the Admiralty and the Government, which resulted in the production after a little time of the 4½ inch plate, familiar to all visitors to the exhibition of 1862, and now to be seen at the Crystal Palace, thrown aside by the front

entrance to the building. For this exhibit, he received the gold medal of the commissioners. A new world opened, and in a comparatively short time three-fourths of the British navy had donned the new fashion, and set an example which was followed by all the foreign navies.

The principle of constructing these plates had long been a bone of contention; some manufacturers and engineers preferring the hammer, and others the roller. Brown strenuously contended for the latter, for reasons we shall hereafter refer to. The gunners and the shot makers pushed on the improvement of their aggressive implements, and Brown settled the controversy by continuing to increase the thickness of his plates, which he could do by rolling. After reaching a maximum thickness of 8 inches, the game seemed to end for two reasons. Whitworth and Armstrong stopped to take breath, and the 8 inch plate added as much to the ship's weight as she could bear with safety.

The sinister rumours current in the political world forbade rest in spite of these circumstances, and the parliament appointed an iron plate committee to ascertain what means could be adopted to assert the supremacy of England on the seas, now that foreign nations had covered their ships with an average of 6½ inch plates. Our superiority stood in peril. Palmerston had ever been most jealous of foreigners in this respect, and with his tenacity of purpose gave the Commons no rest until the whole question had been thoroughly investigated. He had long desired to make a journey into the manufacturing districts and ask his own questions, and observe with his own eyes, all matters connected with this naval architecture and supply; but the strife of parties gave him no rest. The committee pursued their labours, and had visited Sheffield and other places, and taken evidence; but it was not enough to satisfy the chief. Mr. Brown had been pursuing his career as a manufacturer most prosperously, and his sympathies with municipal affairs led to his being first alderman, then mayor of Sheffield. He had invited the premier to come there, and after a time the prorogation of Parliament supplied the favourable opportunity.

At the invitation of Mr. Brown, Lord Palmerston visited Sheffield the day after the prorogation in 1862, and a banquet, most memorable, was prepared. He became the guest of the Mayor at his residence, Shirle Hill, and made the company assembled in his honour right merry with his genial compliments and shrewd good sense. On the following day, his Lordship visited the Atlas Works, where were gathered a large number of visitors. He first inspected the department where armour plates, after welding and rolling, are cut, planed, and slogged, ready for fixing to the sides of the enormous vessels they were intended to make impregnable. A number of plates of various sizes, most of them about 5 inches thick, 14 to 16 feet in length, and 3 to 4 ft. wide, were passed through the various stages, before being sent away to the docks and fitted on the ships. The process interested the Premier very much. The plates were laid upon a horizontal stage, in a way that makes them perfectly firm; the stage then moves backwards and forwards at a slow steady pace, while strongly pointed implements firmly fixed in an iron frame, plane off the iron in thick shavings, as if it were wood of the softest growth. From this department his Lordship walked to the casting department, and saw Mr. Bessemer's process, and the casting. An immense oval cauldron, with a short narrow mouth, was nearly filled with molten metal, conducted into it from adjacent furnaces by an open channel, the metal hissing and foaming, and throwing up sparks as it ran. The mouth of the cauldron being pointed towards a circular iron roof, a strong current of air was passed through the metal, which boiled and foamed and threw off glittering sparks. This purifying process occupied half-an-hour, until the metal became as white as snow and of intense heat, when it was poured into a large basin placed over an upright iron mould of 12 in. diameter at the top. A plug was then removed from the bottom of the basin, and the metal ran slowly into the mould, which when full had to be covered with a thin iron plate covered with sand, and left to cool in the mould, from which its deliverance made it become part of a Blakeney gun. His Lordship next visited the armour plate-works, and forty or fifty men showed him the rolling process. By the aid of huge tongs the men dragged the great mass of red-hot metal from the furnace, upon a lorry, and rushing across an intervening space of 50 or 60 yards, slid it upon the table of a ponderous roller. Again and again did the torrid mass pass backwards and forwards through the roller, which was each time screwed down, to increase the pressure. During the rolling, men with enormous brooms swept the surface of the metal, to remove the blotches and impurities. There it was left to cool, 18½ ft. long, 3 ft. 9 in. wide, 5½ in. thick, and six tons of weight, and composed of 180 layers of iron welded. His Lordship then inspected the hammering department, where 4-ton hammers worked under steam pressure a 10-ton force; here the men were welding piston rods. Then the company inspected a machine for cutting armour plates in twain, after the manner and with the facility of a circular saw upon deal, and from thence to the interesting machinery for making railway-springs and buffers, for which the Atlas Works have had a long and honourable reputation. This visit occupied more than two hours, and gave Lord Palmerston intense satisfaction, which he expressed in a manly speech to the workmen.

One cannot pretend to surprise, that under all these laudatory scenes Mr. Brown's confidence in the invulnerability of armour-plates grew apace. His sanguine temperament had something tangible to feed upon, and he let it find rather bold expression in his public addresses. In the Autumn of 1862, he thus expressed himself at a social gathering:—

"New trades have been brought into the town, and new ones are being introduced. It was attempted to snuff me out when I introduced the iron trade, but I am one of those men who the more they are opposed become the more determined. When I started my little forge, people said I was going to ruin myself; what had Sheffield to do with iron? The answer is, There are now 2000 men making iron in the town, instead of 80, which was the number four years ago."

And again, at another, still more boldly and pointedly:—

"Though we might occasionally be told by the newspaper, that artillery had the advantage of armour-plates, I stand here fearlessly to assert that there is no gun in the service capable of being carried on a ship, that will penetrate one of the armour-plates made at Sheffield. I am so determined to meet any increase in the power of artillery, and Sheffield is making artillery as well as plates, that whatever artillery a ship could now or hereafter be found or made to float, I will undertake, on the part of Sheffield and its iron masters, to find plates, that would repel any ball that the artillery could throw."

But this confidence did not relieve the mind of ministers. The Iron Plate Committee had sent in its report, and the War Department collected information, and from their inquiries felt bound to demand, what had never been thought of, and which they themselves did not believe in the possibility of attaining,—a 15 in. plate. If the reader will imagine what such a thing means, a plate 20 ft. by 18 ft. with a thickness of 15. in.!

Moreover, there were two questions that demanded settlement—the hammering versus the rolling, and a better method of welding. There had been experiments on hammered steel plates at Sheffield required for the Russian Government in 1863, but at 4½ inches thick the 68 pounder gun cracked the hammered plates, not by penetration, but the concussion fractured the back surface in the entire length, and demonstrated the necessity for toughness even at the expense of hardness. The great gun makers had come to a stand. They could each make guns that would damage the target, and the iron plate makers resumed their experiment of combining iron and steel by alternate layers, but, as above stated, it became more and more evident that thorough welding could never be effected when materials so different were to be combined. The thickness had gradually gone up until Brown reached 11 inches, and that target had to face Armstrong's 600 lb. gun. The forts must have 15 inches, said the authorities, and they proposed the use of 3 of 5 inch thick overlaying each other: the manufacturer, however, resolved on attempting 15 inches in a solid mass, and succeeded; but it required the labour of 200 men, and the consumption of 200 tons of coal. And as to the toughness, Mr. Brown did his best to meet that, for he possessed some knowledge of metallurgy, and much skill in managing the fusion and welding. The old plan of welding was to make a number of plates of the best cold-blast pig iron from different districts; these were amalgamated in the furnace, then passed to the hammer, reheated and rolled into thin slabs. Several of these were then laid together heated and rolled until say 2½ or 3 inches had been acquired. These in their turn were heated, and the rolling repeated, until the desired thickness was produced. But in the last stage, an insurmountable difficulty arose in consequence of the impossibility of maintaining sufficient heat in so dense a mass. This Mr. Brown overcame by providing cubes of highly carbonised iron about an inch square, and placing them between the slabs, thereby admitting the free action of the flame to the entire surfaces of each slab at one time, and of equal heat. In the process the cubes melt away, and before the time of fusion the slabs settle down and form one united mass; the heat is then increased until the metal is at white heat, when the final rolling is effected. The handling of these terrific bulks is awfully laborious and exhausting. The dragging of the blocks from the furnace is effected by a steam crane gripping enormous pinchers, which have to be attached by labour; then it is taken to the rolls,

rolled backward and forward until the bulk is reduced to the desired gauge, which takes about 15 or 20 minutes.

This 15-inch plate solid, turned out to be equal to twenty or twenty-two of the combined; and then followed some interesting experiments at Shoeburyness in 1867, which so satisfied the crown, that Mr. Brown received, in November of that year, the honour of knighthood "for developing the clothing of ships of war with iron and steel," and at the exhibition at Paris in that same year, he obtained the gold medal, held the office of master cutler in Sheffield, and was a prominent actor in the successful enlargement and improvement of the splendid hall.

During his two years' mayoralty he is said to have distributed £6000 or £7000 in charitable and hospitable public matters. He erected a church for his work-people and their families; raised from the works two companies of rifle volunteers, equipping them at his own charges; is town trustee and church burgess; governor of the Deakin Institute; has been president of the Yorkshire Choral Union, the public hospital and dispensary, and a director of the Manchester, Sheffield, and Lincoln Railway. The electors of Sheffield offered to place him in parliament without opposition, and without reference to politics, but this was declined, as was also the offer of a third mayoralty. His labour in connection with the Lancashire distress, was worthy of the town of his nativity, and his example of collecting by the workmen in small sums, was followed in many a northern factory. By twopence per month from men, and one penny from boys, they raised £89. Sir John Brown still holds an interest in the Atlas Works, and is director of joint stock companies, connected with the Iron Trade of Yorkshire and Lancashire. W. S. C.

FILES AND FILING.

By Joshua Rose.

THE file is one of the oldest of tools of which we have any knowledge, nor is there any probability that its employment in the mechanic arts will do other than to maintain its position, for the simple reason, that properly made and in skilful hands it will perform a duty unequalled, for truth and smoothness, by any other known tool. It is an utter fallacy to suppose that the introduction of either fast running grindstones or emery wheels have encroached upon the legitimate domain of the file, nor can they ever do so, for the use of these abrasives has only diminished the number of cases in which files were put to a rough and destructive duty by the reason of the non-existence of any other tool applicable to the case, and even here the file holds its own in a large majority of instances, because it is a tool complete in itself, independent of steam power, and can be used in any position, and under almost any conditions. It is folly to tell a really good mechanic that a file can be dispensed with in the ordinary production of good work for the reason that machine-cut surfaces are not cut true. Let us start with the milling machine. It will produce and reproduce work of peculiar form with a reasonably good fit, and with accuracy of outline and dimensions, but the surfaces are not true, and we have never yet seen the piece of milled work, even though got up for especial exhibition, that could not be improved by the file, in skilful hands, both in fit and finish. If any one wishes to satisfy himself upon this point let him take any piece of flat milled work, such as a connecting rod key, and test it upon a surface plate, and he will find that it is not true, and furthermore, that it will take considerable filing, using a twelve or fourteen inch flat smooth file, to bring it to a true surface. This same fact also applies to planed surfaces; nor need we look far for the reason. To hold a piece of work sufficiently firm to be able to operate upon it in a machine, we must place it under considerable strain or pressure, and this springs the work out of its natural form, and so soon as it is removed from the machine, that is to say, released from the pressure, it springs back again to its original form; and the file is the only known tool that will properly correct the evil. It is easy to claim for machine-finished work all the excellencies pertaining to file fitted work, but the surface plate or any equivalent test will pronounce such claims untenable. It may be true that we may fix our standard of excellence at such a point that machine-work will fill its measure; but this is in no way desirable or even profitable, because a piece of work that fits, so far as there being no lost motion is concerned, will nevertheless get lost motion from wear, in precise proportion to the area of surface in contact, or in other words, in proportion to the fit, and as an illustrative example, we may note the fact that Mr. Brown, of Fitchburg, Mass., had an engine running, at the Centennial Exhibition, with the slide spindles and stuffing boxes such a fit that they are steam-tight without the use of any packing, running tight for months.

The file is not by any means the rude instrument that the ordinary observer would suppose it to be; every part of its manufacture requires the greatest of care and skilful manipulation, and even then the hardening may often partially destroy its value, by warping it more or less; and so important is this element, that the success obtained in the past by the Stubbs and Grobet files has been very largely due to the correctness of their outlines. A file should be of an even sweep from end to end, and while it is all that is necessary to have it bear evenly across its width, it is an improvement, if the teeth are a little higher along the middle of the length of the file, but in no event should it be hollow in its width, for it would then at every stroke file two grooves.

To produce files by machinery, and equal to those cut by hand, has been a problem, to the solution of which the mechanical world has directed continuous effort for many years past, and in working it out success has been but slowly attained. As an unfortunate consequence workmen have a prejudice against machine-cut files, which prejudice is not warranted, in view of the quality of such files as are at present made. There is much to excuse in this tenacity with which the workman has clung to the hand-cut file, for the claims put forward on behalf of the machine-cut files at a time when their manufacture was in its infancy, and mere experiments in fact, have caused the workman to employ excessive caution in according to them the credit due to their merits, or in other words, the failures of the past are a load which the manufacturers of the present have to carry. That this load is becoming lighter, there is no doubt, and there is every reason to believe that the time is not far distant when machine-cut files will be the rule and hand-cut the exception. It is the users of the files who require convincing, that is, the actual operatives. The writer himself, after over twenty years' experience, and many trials, had come to the conclusion that the day was far distant when the reputation of hand-cut files would have anything to fear at the hands of its rivals. A close inspection, however, of the exhibits at the Centennial Exhibition, demonstrates that so far as the eye and judgment can determine, the machine-cut file will bear the closest comparison with its rival, and this is more than we can say for any of the machine-cut files he had in previous years inspected.

Among those exhibits, that of the Nicholson File Co.'s is prominent, not only on account of its size and completeness, but also for the reason that it contains the only variation to the form of the cut of a file which modern times has produced. This variation consists in giving to the file what is called an increment cut, that is to say, the depth and width apart of the teeth are made variable, as well as their heights, and the theory upon which this method of construction is evidently based is as follows:—

The amount of cut a file will take at a stroke depends upon the amount of area of cutting edges in contact with the work and the pressure placed upon the file; it follows then, as a general rule, that the less the area of cutting edge (under a given amount of pressure) the greater the amount of metal removed. Now if the file teeth run in such regular lines that they cut grooves, the area of the cutting edge in contact with the work increases proportionately, and the cutting duty is diminished. This fact is recognised by all expert workmen, in the fact that upon all broad, or comparatively broad surfaces, they resort to expedients to overcome the regularity of even hand-cut files. Thus, for instance, in filing up a broad surface where the ordinary file handle is replaced by an iron "raised handle," which will allow the tang of the file to pass over the work, the mechanic, if he wants to remove a quantity of metal, casts his eye down the length of the file and selects the side most rounding in its length, and as a consequence only a comparatively small area of file teeth can come in contact with the work, and by raising or lowering the handle he can first use the end, and when that gets dulled, the middle and so on of the file. He finds, however, that this increases two existing defects, that is, the file cuts grooves, or channelings as it were, which causes the cutting to clog in the teeth, and this is called "pinning." The cutting is also impeded by the large area of cutting edge in operation. To remedy these two defects he files so that at every few strokes the file marks cross each other; even on ordinary or small work he does this. The evil of "pinning" is a very serious one, for the pins prevent the file teeth from cutting by obstructing their contact with the work; then again, a file card will not remove them all, and hence the small strips of sheet-brass, flattened out at the end, and with serrated edges, which are to be found on all machinists' vise-benches, and which are used (to remove the pins) by being forced across the width of the file, and in a line with the rows of teeth. This process

GERMAN ART WORKMANSHIP.

injures the file teeth by dulling them, because the brass meets the edges in a line with their fibrous edge, and thus in a direction in which that edge is in a measure unsupported. In smooth filing and draw-filing "pinning" is very disadvantageous, because the "pins" cut scratches in the work, and it is no exaggeration to say that in fine work it takes more time to guard against and remove the scratches thus produced than it would otherwise take to do the whole finishing. To prevent "pinning" when using files subject thereto, the workman takes two methods, first, he may keep the file well oiled, but this keeps every tool about him dirty, and entails constant attention in oiling and cleaning the file; hence it is much more common, and better, to well chalk all the file teeth, and after every few strokes to brush the hand over the file, and tap the same on the screw box of the vise, which removes part of the chalk, and with it the filings; then every few minutes fresh chalk is applied. In filing thin metal such as sheet-iron, plate-iron or saw-blade, "pinning" is an especial nuisance and great defect, because it interferes with the operation at every few strokes, providing much pressure is placed upon the file, and this is a consideration that applies especially to the use of mill-files and smooth-files, whether the latter be used to draw file or to cross file, for the workman will prefer to use the file very lightly rather than be subject to the annoyance of having to remove the "pins" from the file. Job's patience was never really tried, for he never had a fine piece of work to be finished with a file liable to "pin."

The object of the increment cut is to ensure that the rear teeth shall remove the projections made by the front ones, and not cut in the hollows, and this, it is claimed, it so effectually does as to remove the "pinning" difficulty to a considerable degree, and at the same time permit the operator to employ as much force as he desires upon the file. The subject is an important one, and we shall not lose sight of it.—*The Polytechnic Review, Philadelphia.*

WOOL DYEING.*

By George Jarmain.

Lecture IV.

Logwood.

PERHAPS, with the exception of madder, there is no one dye-ware which has such extensive application as logwood, and in wool dyeing, in which madder finds more limited use, no other ware can be compared to logwood in utility. The use of proper mordants, and a better knowledge of the properties of the colouring matter of logwood, have enabled dyers to obtain such fast and permanent colours with it, that the ban under which it formerly lay, arising from the fugitive nature of the colours obtained by the dyers who first used it, has long since passed away.

The natural history of logwood and other woods and wares which I shall have occasion to deal with, together with the properties of their colouring principles, have been so well described by my predecessors on this platform, especially by the late lamented Dr. Grace Calvert, that I do not deem it necessary to enter into that full detail which I should otherwise have done, and I therefore intend to dwell more at length on the special properties of the colouring matters which much concern the practical dyer, and also on those various details of the dye-house which are so essential to the successful prosecution of the dyer's art.

Logwood is imported into this country from Central America and some of the West Indian Islands in blocks or billets.

That brought from Campeachy is esteemed the best, but is now scarce, and the price is high. The next best is Honduras, of which there is a large consumption in the woollen trade. Jamaica and St. Domingo are common qualities which are also in considerable use.

Logwood is the wood of a large tree belonging to the Leguminosæ family, and is called *Hemaloxylon campechianum.*

It is prepared for the use of the dyer in the three following forms:— 1st, in chips; 2nd, ground or in raspings; 3rd, as an extract, which is the solid or semi-fluid residue obtained by evaporating the decoction of the wood.

The colouring matter is developed by moistening the chips and raspings with water, and allowing the mass to ferment slightly in a heap, taking care that the fermentation does not proceed too far.

The water used for moistening the logwood should be free from iron or peaty matter, both of which damage the appearance and quality of the wood.

The chips of good logwood gradually become coated over with a green colour, somewhat like that reflected from a beetle's wing.

When the chips are used for dyeing, which is the most common form in which logwood is employed for wool and heavy pieces, they are placed in a bag made of course open material, and hung down into the boiling water, which is intended as a dye-bath, until the colouring matter is extracted; the bags are then removed, and the material to be dyed put in.

Rasped logwood is thrown into the dye-bath along with the material to be dyed.

The colouring matter of logwood assumes two conditions:—

1. A colourless condition, called hæmatoxylin ($C_{16}H_{14}O_6$).
2. A coloured principle, called hæmatëin ($C_{16}H_{12}O_6$).

The difference, it will be observed, between the two is similar to that which obtains between indigo white and indigo blue, namely, a difference of two atoms of hydrogen.

The oxidation of the colourless hæmatoxylin results in the formation of the coloured hæmatëin from exposure to air. These facts were discovered by M. Chevreul.

The colouring matter does not exist in either condition in the wood itself, but is the result of the fermentation of a glucoside.

The hematëin is susceptible of further changes under the influence of ammonia.

The colouring principle, hæmatëin, is the body which the dyer uses as a tinctorial agent; it is that which gives the red colour to the prepared dyewood; and the green substance, with green cantharides reflection, which is seen in the chips, is the hæmatëin which has effloresced from the damp logwood and dried on the surface.

Logwood Colours.

A variety of shades of colour can be obtained with logwood alone as the colouring agent; and it enters into the composition of a still greater variety of composite colours. It is essentially a blue colouring matter, and is hence frequently called by the French *bois bleu.* The shade of colour which it imparts to wool is very much modified by the various mordants. Logwood colours are affected by acids which turn them red, and alkalies which change them to blue or purple. By varying the quantity of logwood, various shades of blue are obtained from lavender, with 2 per cent. of logwood to a dark blue with 30 per cent., which shade becomes very dense and full when the percentage of logwood is increased to 60 or 70 per cent. The darker of these colours are constantly produced in the dye-house, both on wool and cloth.

Recipes.

Though dyers' recipes are often instructive in indicating the directions which the dyer may take in order to obtain any given colour or shade of colour, the conditions under which he may work are subject to such a great amount of variation, that I deem it necessary at the outset to give a word of caution, and to impress upon him the fact, that the literal interpretation and carrying out of almost any recipe will produce results alike in the hands of no two dyers, who may happen to be differently circumstanced.

This is readily accounted for when we consider that the wares may be different in the percentage of colouring matter and tone of colour, the mordants of varying strength, the water often altogether different in quality, the varying dimensions and kind of dyeing vessel used, the different effects of steam and fire heat, and the variations produced by operating on a larger or smaller weight of material. In fact, the varying conditions are so numerous, that dyeing recipes are often illusory, on account of the differences which have been enumerated above. The recipes which I shall, therefore, have occasion to give from time to time, I wish to be accepted with caution, and interpreted with some latitude as to quantities of dye wares, &c.

The recipes are given as typical examples of processes in actual use in the woollen districts, in dyeing goods on the large scale, and are not put forward as the very best modes; these can only be found out according to the different circumstances under which a dyer is placed, and they are often only the result of careful observation and long practice.

The term fast is used in the recipes for a colour which will fairly withstand scouring and milling, but not necessarily the action of light and atmospheric influences. By permanent is meant a colour that will withstand all deteriorating influences both in milling and scouring, and also those to which it may be subjected during a reasonable time of wear. The terms loose

* A Course of Cantor Lectures, reprinted by permission from the Journal of the Society of Arts.

and fugitive are applied as opposites to fast and permanent. These definitions are given, not as representing what is frequently attached to them by authors on dyeing, but as those which I wish to be attached to them in these recipes, and which I think may be conveniently applied. The recipes are all given for 100 lb. of wool or cloth, except when otherwise stated.

Common Black at one Operation.

	* Per cent.
Logwood	40
Sulphuric acid	0·5

Boil half an hour.

Copperas	3
Blue vitriol	1

Throw on solid or in solution, and boil half an hour longer. Let off, and leave over night.

Colour loose, turning brown in the wear, used for dyeing coloured waste intended for low-class goods. Sumac might be used with advantage for a black of this description.

This is a loose colour, because a good deal of the colouring matter is converted into a lake, and is therefore only loosely attached to the fibre. "The old dyers generally dyed in one bath only, which in part explains the bad results obtained." †

Common Doeskin Black.

Mordant—

	Per cent.
Copperas	3½
Blue Vitriol	2
Alum	2
Red argol	3
Logwood	3½

Boil for five minutes, cool down to 100° Fahr. with water, enter the goods, raise to the boil in three-quarters of an hour, and boil for an hour and a half. Lift out, and leave over-night. Some dyers wash off, others leave unwashed.

Dye—

	Per cent.
Logwood	24
Red argol	1

Boil for five minutes, cool down to 180° Fahr. with water, enter the goods, raise to the boil in half an hour, turning by the wince—quickly at first—and boil for another half hour, wind out, cool down over the perch, and wash on the machine with fuller's earth.

If the goods have been manufactured partially from mungos, which often contain cotton threads, commonly called burls, it will be necessary to burl-dye them, an operation in which the particles of cotton are dyed black. This operation consists in steeping the cloth in a cistern containing an infusion of a tannin material, commonly sumac or myrabolams, afterwards passing them through a solution of pyrolignite or so-called nitrate of iron (nitro-sulphate of iron). The pieces are then finally washed on the machine with fuller's earth. Colour fast, but not very permanent, becoming brown in the wear.

Doeskin Black for Wool.

	Per cent.
Camwood	8

Boil for for 50 minutes. Then add :—

Bichrome	3
Alum	1
Argol	1

Boil for 50 minutes, let off, and allow to stand over-night.

Dye in—

	Per cent.
Logwood	45
Fustic	8
Sumac	4

Boil for 1½ hours ; let off. Colour fast and permanent.

This formula contains all the colours necessary to produce a black, namely, red, blue, and yellow. Camwood furnishes the red, logwood the blue, and fustic the yellow. Chromed logwood colours have a tendency to become green, from the production of chromic oxide ; the presence of camwood or other red colour makes this change less apparent.

Chrome Black with Blue Reflection (blue through) for Wool.

Mordant—

	Per cent.
Bichromate of potash	2
Sulphuric acid, D.O.V.	0·25

Boil 1½ hours, and leave over-night.

Dye—

Logwood	45 to 55

Boil one hour.

* The percentages given in this and the following recipes are for 100 lb. of wool or woollen fabric.

†Van Laer.

If required very clean, as in mixtures of black and white (black and white checks for example), the colour may be fixed more firmly by finally passing it through a warm bath containing 5 per cent. bichromate of potash.

Chrome Black with Violet Reflection (violet through) for Wool.

This is mordanted and dyed as the last. The violet reflection is obtained by using the following modifier :—Single muriate of tin, 1 to 2 pints. Mix the tin spirit in 20 or 30 gallons of water and throw it on the wool, handling up for 15 minutes.

Chrome Black with Green Reflection for Wool.

Mordant—

	Per cent.
Bichromate of potash	2
Sulphuric acid	0·25

Boil 1½ hours, and leave over-night.

Dye—

Logwood	40
Fustic	10

Boil one hour.

Colour fast and moderately permanent, becoming greener and paler.

Woaded Blacks.

These are the best blacks for either cloth or wool ; they are obtained by first dyeing the goods in the indigo vat a light or medium shade, and then dyeing them as for chrome blacks, using less logwood in proportion as the indigo bottom is more or less dark. Colour fast and permanent.

Lavender on Wool.

	Per cent.
Alum	1½
Tartar	0·25
Logwood	2½
Indigo extract	0·25

Boil for five minutes, cool to 180° Fahr. with water ; enter the goods, and boil for one hour. Let off and wash. Colour moderately fast.

CUDBEAR, ARCHIL PASTE, AND ARCHIL.

These colouring matters, though not obtained from wood, may with advantage be described here, as they are often employed with logwood and the other woods in many composite colours ; these three colouring matters are all obtained from the same sources ; namely, certain lichens or weeds, the two principal species of which are *Rocella tinctoria* and *Rocella fuciformis*.

The weeds contain no colouring matter, this being produced by exposing them to the action of ammonia. Drs. Stenhouse, Schunk, and others, have investigated the colouring matter contained in these dye wares, and have found several distinct colouring principles in them.

Cudbear is made by drying archil paste, and then grinding the residue to a fine powder ; the colouring matters of cudbear are more red than those of archil, but even these may be varied by differences in the manufacture, both red and blue archils being produced for the market.

These colours are employed largely as a bottom or ground for indigo on wool or cloth, and also, as before stated, for many mixed or composite colours, but the colours are somewhat fugitive.

The mordants affect the shade of colour only to a small extent, in fact, they may be employed without mordant. They are most affected by a mordant of tin, chiefly through the influence of the free acid contained in the tin spirit, which, like all other acids, reddens and brightens the colour, changing it to a maroon. The weed colours, as they are called, are mostly used for the purpose of modifying and blooming other colours, but as they are fugitive, the bloom soon passes away. Their brightness and beauty, however, render them exceedingly well adapted for the colours required for ladies' wear.

The following formula is given as an illustration of the use of cudbear along with logwood :—

Logwood Blue for Wool.

Mordant—

	Per cent.
Bichromate of potash	1
Alum	3
Tartar	1½

Boil for 1½ hour, let off, and leave over-night.

Dye—

Logwood	20
Cudbear	1

Boil for one hour, then throw on 20 quarts single muriate of tin,

diluted with 20 or 30 gallons of water. Handle up for fifteen minutes; let off and wash. Colour moderately fast.

The Red Woods.

These important dye wares comprise two classes:—1. Red woods, whose colouring matters are freely soluble in boiling water; these include Brazil-wood, Lima-wood, Santa Martha or peachwood, Sapan-wood, and Pernambuco-wood. 2. Red woods which are almost insoluble even in boiling water; these include camwood, barwood, and sanders-wood, and caliatour.

The first class is imported in the form of blocks or billets from Central and South America and the West Indies, and is sold to the woollen dyer in the powdered state. They are said to contain the same colouring principle, called by Chevreul, who first obtained it, by the name of brazilin; it can be obtained iu needle-shaped crystals, which are nearly colourless, and have a bitter sweet taste. By oxidation it is transformed into braziliëin, by a change which is analogous to that which takes place when indigo white becomes indigo blue, and when hæmatoxylin becomes hæmatëin. The change may be expressed by the following equation:—

$$\underset{\text{Brazilin.}}{C_{22}H_{18}O_7} + O = \underset{\text{Braziliëin.}}{C_{22}H_{16}O_7} + {}_7H\ {}_2O$$

I find that peachwood is almost the only wood of this class which is employed in wool dyeing, and that only to a limited extent; it is never used as a self colour, its chief employment being for the purposes of imparting a purple tone to other colouring matters.

The second class, embracing camwood, barwood, sanders-wood, and caliatour, is very important to the woollen dyer. They are the produce of several species of Pterocarpus, which grow in tropical countries, and are imported into this country in the form of knotty billets or blocks, which are prepared by rasping for the use of the dyer; the wood, on account of the very slight solubility of its colouring matter, is generally boiled in contact with the article to be dyed. The colours which they impart to wool are red, or red brown, with a mordant of tin, alum, or bichrome, the colour being of a dull shade when copperas is used; the colours are very permanent and fast, and are on that account much employed in the dyeing of wool and woollen cloths which have to be scoured and milled.

The colouring matter seems to be the same in all; there is a colourless principle called santal, which by oxidation is transformed into the red colouring matter, santalin, by a reaction analogous to those which take place in the colouring matters of indigo, logwood, and peachwood.

These woods are seldom or never used alone as a colouring matter for wool, their principal employment being to give the requisite red tone to browns, clarets, violets, maroons, blacks, and other colours which contain a red in their composition; they are also the best bottoms for indigo which can be put on, being much faster and more permanent than a bottom obtained with archil or cudbear.

Claret Brown on Wool.

Mordant—

	Per cent.
Bichromate of potash	1½
Sulphuric acid	0·25

Boil for one hour, leave over-night.

Dye—

Camwood	34
Barwood	10
Logwood	2
Cudbear	1

Boil for two hours; let off.

The shade may be considerably darkened by the addition of copperas towards the end of the operation.

Madder.

This colouring matter is more extensively used by the cotton dyer and calico printer than it is by the woollen dyer. It has been the subject of much research, and the composition and nature of its colouring principles are now well understood. It has long been used as a dye stuff; the ancient Egyptians, the Greeks, and the Romans are said to have used it.

Though not a wood, it will be best to discuss it here in connection with the red woods, as it holds, as a woollen dye, a position intermediate between that of the red woods and the yellow woods. It is the root of a plant called *Rubia tinctorum.*

Dr. Schunk states that the colouring matter exists in the plant as a glucoside—that is, in combination with a sugar. He calls the glucoside rubian.

The principal colouring matters yielded by madder are alizarin, purpurin, and pseudo-purpurin, of which the first is by far the most important, being the only madder colour which may be considered fast and permanent.

The artificial production of alizarin from anthracene, one of the products of the distillation of coal tar, is one of the most important and interesting applications of chemistry to the arts that has been made of late years.

In 1868 Græbe and Liebermann found that when alizarin and zinc-dust were distilled the hydro-carbon anthracene was obtained, and by reversing the process they succeeded in obtaining alizarin from anthracene. The artificial colouring matter seems to possess all the properties of the alizarin of madder.

I am not aware that artificial alizarin has yet been used in the woollen districts as a dye for wool.

In wool dyeing the chief uses of madder, besides acting as a ferment in the indigo vat, are for the production of drabs, browns, and olives, for which its colouring matters are well adapted. The colours obtained with madder on wool are very fast and permanent.

Brown on Wool.

Mordant—

	Per cent.
Bichromate of potash	1
Sulphuric acid (D.O.V.)	0·5

Boil one hour; let off and leave over-night.

Dye—

Madder	11
Logwood	1
Camwood	8
Fustic	10

Boil for two hours; colour fast and permanent.

Mode of Testing the Value of Dye-woods.

The best practical test that the dyer can employ is to dye swatches of cloth of equal weight with equal weights of the dye to be tested, and of a known good sample, and comparing the results in each case. The master dyer will find it to his advantage to test his dyes himself, by which means he will be able to know when he is having full value for his money.

A MODE OF GENERATING SULPHUROUS ACID GAS FOR USE AS A DISINFECTANT, &c.

By Thomas W. Keats,
Consulting Chemist to the Metropolitan Board of Works, &c.

THE effect of sulphurous acid gas as a disinfecting and antiseptic agent is too well known to require to be dwelt upon. All persons know its value who are acquainted with sanitary questions, but the difficulty has been to obtain it conveniently and readily, and under such conditions that it could be applied with facility when it happened to be wanted.

Sulphur burned in the air will produce double its weight of sulphurous acid; but the burning of sulphur is not convenient, and, indeed, not easy without a proper arrangement for carrying on the combustion. Sulphurous acid is soluble in water, and is afterwards again slowly evolved from the water in the gaseous state; but the solution requires to be made beforehand, does not keep well, and, again, is not always easy of application where the disinfectant action is required.

Sulphurous acid in the gaesous form can, however, be obtained with the greatest facility and under circumstances which render it applicable, I believe I may say to all conditions in which such an agent can be used, by the simple expedient of burning the liquid called bisulphide of carbon.

Bisulphide of carbon is a colourless, heavy liquid, sinking in water, excessively volatile and inflammable, burning with the greatest avidity, with a livid blue flame, and giving off abundance of sulphurous acid gas, and, what is of importance, it can be burned in a lamp like spirit of wine; it is this quality which renders it so remarkably suitable to the object in question when considered in connection with its chemical constituion.

Bisulphide of carbon, as its name indicates, consists of an atom of carbon united to two atoms of sulphur ($C S_2$); 100 parts by weight contain 84 parts of sulphur, and 16 parts of carbon. This quantity of bisulphide yields, in burning, 268 parts of sulphurous acid, and 58 parts of carbonic acid calculated in grains, the 168 parts of sulphurous acid measuring rather less than 250 cubic inches, or about one-seventh part of a cubic foot.

Many experiments have been made with the view of ascertaining the effect which the burning of a given quantity of the

bisulphide will produce upon the atmosphere in which the burning takes place. The result of these experiments is, that about half an ounce by weight will impregnate a thousand cubic feet of air with sulphurous acid, to such an extent that it is rendered irrespirable for more than a few moments; and it may be assumed that in such an atmosphere disease germs and the products of putrefaction would be entirely destroyed, and the air effectually purified and disinfected. The time required for burning half an ounce of the bisulphide in a lamp of the size of a common spirit lamp is about 20 minutes, and in that time the quantity of air mentioned will be completely charged with sulphurous acid throughout its volume.

The application of this method of generating sulphurous acid is so simple and convenient, that it can be used in almost any locality, and obviously not only for the disinfection of the place, but likewise of the materials which it might contain; so the bedding and linen of fever patients, or the interior of a vehicle in which they have been carried, can be completely purified with very little trouble and at the cost of very few pence.

Sulphurous acid is considered by most skilled persons to be the most effective of disinfectants where it can be used, but the ordinary method of obtaining it by burning sulphur precludes its employment in most cases. The burning of the bisulphide of carbon, on the contrary, is as easy as the burning of a little spirit of wine in a lamp under the coffee-urn, and it can be carried on in the most inconvenient places and in a very limited space. On board ship it can be used with advantage, not only for disinfection in cases of contagious disease, but also for ordinary fumigation, and I think it would be found of value in tropical countries in connection with the treatment of the virulent fevers of those regions.

There is another application of the employment of bisulphide of carbon to which it might be useful to advert. I mean in destroying the fungoid growths which occur in casks that have contained beer and similar liquids. Burning sulphur is the specific in those cases, but the burning bisulphide is more convenient.

In using this agent, it must be borne in mind that it is extremely volatile, intensely inflammable, so that in filling the lamp no light should be near at hand, and that the odour of the bisulphide itself is rather disagreeable, and therefore the bottle in which it is kept should be well stopped, and the lamp fitted with a good screw cap to keep in the odour, and at the same time to prevent the evaporation of the liquid.*

RAU'S ILLUMINATED DIAL PRESSURE AND WATER GAUGES.

WHOEVER has to look after the working of a number of steam generators, cannot be at ease as to the safety of the machines, and especially as to the boiler's proper action, until he has ascertained the level of the water in the indicator tube to be at its right elevation, and the position of the indicating needle of the pressure gauges at the desired division on the dial. It is also well known how rare it is in practice for this inspection to be possible with despatch and certainty in industrial establishments, cabins, engine-rooms of vessels, and even on the platforms of locomotives.

The reasons for this deplorable state of things are not hard to find, if one considers the position in front of the boiler, in which these instruments of safety are generally placed. In most cases they are at a greater or less height above the door of the fire-place, and as smoke-consuming consumption is up to the present time an unsolved problem, thick clouds of smoke and coal dust come and settle on the glass indicator tube, and the dial of the pressure gauge.

If this renders the reading of the indications of these instruments difficult in the daytime, the task is still more difficult at night, especially with the present defective mode of lighting them. In boilers called fixed, a jet of gas or an oil-lamp casts its rays on to the level tube, or manometer dial. These rays meet the observer's eye after being reflected by the surfaces of these two instruments. The surface of the tube, at once reflecting and refracting, is, as to the latter point, corrected by the refracting power of the different rays for the column of water inside the tube, and the glass walls of the tube itself. But as to the manometer, the bad effect is not at all mitigated. On the contrary, it is aggravated by the following optical phenomena.

In the first place, it is proper to recall the principle of physics on which the Rumford photometer was based, that a non-transparent object between the source of light and the observer's eye, casts a shadow, the intensity of which increases in the inverse ratio of the squares of the distances. In the second place, the observer's eye, in order to see clearly an object reflecting luminous rays, ought not to receive direct rays. This last inconvenience might to a certain degree be considerably reduced by the use of a reflector, concentrating the rays by casting them on the surface to be lighted. But the difficulty of the shadow cast by the needle of the manometer can be overcome, only by arranging the lighting in such a way, that the ground on which the needle is placed, should receive direct luminous rays and more intense than even the needle, or in other words, that the dial of the pressure gauge should be interposed between the source of light and the observer's eye. That can be obtained only by placing the lighting apparatus inside the box of the manometer, and using a dial transparent to the light, though presenting an opaque appearance by day.

As pressure gauges having a dial of 150 millimetres (5¾ inches in diameter) often have divisions from 0 to 12 atmospheres, the shadow cast by the needle with an outside light, often occupies the space equivalent to the division corresponding to a quarter or half an atmosphere, which is not without danger when once the maximum pressures are reached.

Considering all these defects of the old system, and the exigencies of practice, M. E. Rau of Brussels has constructed the system with a light inside for manometers indicating vacuum, and the application of which to apparatus of Schaeffer and Budenberg system is rendered intelligible by figs. 1 and 2.

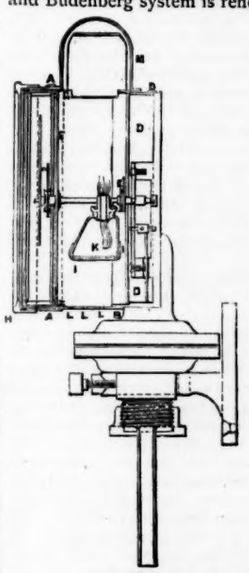


Fig. 1.

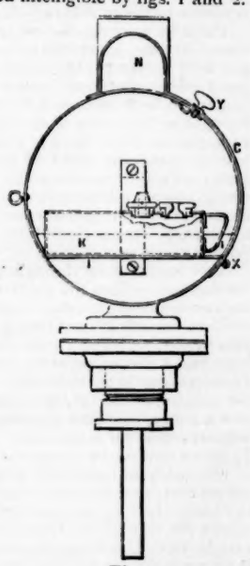


Fig. 2.

However simple this invention may seem, its realisation presented serious difficulties. In an instrument of small size, and the mechanism of which is composed of pieces of clock-work, it was necessary to prevent a flame burning inside from deranging metallic organs and causing false indications by producing a high temperature. Add to this the necessity of guarding against the breaking of the apparatus by shocks from the trepidation of a locomotive passing over crossings, and against the blowing out of the flame by the wind, and it will be easy to understand the difficulties to be overcome before it was possible to produce an apparatus indispensable for every generator working in the night or in dark places. Without entering into a detailed description, which is rendered needless by the figures in our illustration, we will merely call attention to the circumstance, that, to facilitate the exchange of pressure gauges unfit for further use for new ones, while still preserving the lighting apparatus, M. Rau, co-operating with Messrs. Schaeffer and Budenberg, has placed the light in a special box behind the mechanism, and separated from it by a glass partition.

The Rau system is now in general use. There are more than 3000 apparatus at work. The system obtained the diploma of honour at the exhibition of the St. Petersburgh Polytechnic Institute in 1874-1875.—*Moniteur Industriel Belge, Jan. 1, 1877.*

* A convenient arrangement of lamp and case is made by J. How and Co., of St. Bride's Street, Ludgate-Circus.

CHAUMONT'S APPARATUS FOR HEATING RAILWAY AND OTHER CARRIAGES.

THERE are two general systems of heating railway carriages, one by foot-warmers, and the other by the radiation of heat in the air. Each of these systems is attended with certain inconveniences which it is not necessary to describe in detail. In Belgium they appear to have decided upon the use of foot-warmers. This system has the important advantage of communicating the greatest heat where it is most wanted—under the feet—which are most susceptible of cold. Being moveable, the foot-warmers can be put in the carriages and taken out of them without any special arrangement for the purpose.

Till within a few years the foot-warmers were always filled with hot water, and this plan is still almost universal; but experiments made with other modes of heating—especially M. Chaumont's gas foot-warmers—render it not improbable that changes will be made ere long.

The ordinary foot-warmers are attended with serious inconveniences. They give a very imperfect heat, and soon get cold, which causes great trouble and expense in changing them, as well as wear and tear both of the foot-warmers and the apparatus for heating the water; the carpets and mats soon get out of order; and the changing causes delays and inconvenience to the travellers.

These inconveniences are avoided by the use of M. Chaumont's system, which has been tried with success for three winters with a train consisting of twelve carriages of three classes, and running constantly between Brussels and Antwerp.

The foot-warmers are fed with gas, and the apparatus used for lighting the trains is also employed for warming them. In each compartment there is a foot-warmer of galvanised sheet-iron all along the width of the carriage. It has two pipes inside, in which circulate the products of the combustion of two gas-lights enclosed in two small cast-iron fire-boxes placed at the ends of the foot-warmer. These fire-boxes, fixed outside the carriage, under each door, have a little door easy for the porters to get at.

After having gone through the pipes, the products of combustion escape into the air through small chimneys hidden in the corners of the carriage rising above the roof. The air in the foot-warmer around the pipes, being of small volume, soon gets heated by contact with the pipes, and in a quarter of an hour raises the temperature of the sheet iron to about 167 deg. F., which continues unaltered at every point, in consequence of the position of the two gas-lights at the two opposite ends of the foot-warmer. Besides warming the passengers' feet, the foot-warmers raise the temperature of the compartment about 180 F. above that of the common air, which is generally sufficient.

This mode of heating is evidently very simple and easy, requires no labour during the journey since there is no occasion to change the foot-warmers, and is free from danger of fire. It allows the regulation of the heating of each compartment as may be desired, and, as it soon gives the required heat, there is no necessity for heating long before the departure of the trains, as is unavoidable with systems in which solid combustibles are used. The apparatus can be easily removed in summer or in case of accident, and easily put back again. The complete apparatus for a compartment costs about £5, and the expenses of working with rich compressed gas are not more than a half-penny an hour for each compartment, and less than a farthing with ordinary town gas.

M. Chaumont has also invented another kind of foot-warmer, consisting of a box of variable dimensions, according to requirement. The upper surface is formed of sheet iron about three quarters of an inch thick, slightly arched, and fixed firmly on two upright wooden sides, the two ends of the box being open. A drawer sliding into the box has at different points a glass or porcelain receptacle, in which is placed a flat candle of special make. The heating is not effected by direct radiation from the flame of the candle, but is produced by the constant circulation of hot gases in the space adjoining the sheet iron, which is thus raised to about 158 deg. F. in a quarter of an hour.

The air necessary for maintaining combustion enters through the open ends of the box. Openings are made especially for this purpose on the one hand in the fore part of the bottom of the drawer, which is always slightly raised, on the other in the lower part of a partition which goes between the two upright sides of the box, and forms its bottom, so to say. After having served for the combustion of the candles, the air goes and circulates in the space adjoining the cover of the foot-warmer, and escapes above the front of the drawer and the partition. The temperature remains constant during the whole journey of seven or eight hours. A simple and firm fastening fixes the drawer in the foot-warmer, and thus prevents the candles from reaching the passengers.

The principal advantages of this method are the facility of lighting and the rapidity of heating. The apparatus is solid, requires no attention on the way, and may be slipped under the seat when it is not wanted. Another advantage is the saving in material. Hot water foot-warmers requiring to be changed every hour, there must be six for a three hours' journey, whereas two hot air foot-warmers are sufficient, which is a saving of 66 per cent. There is also a saving of 20 per cent. in the cost of heating.

It may be objected that this system is unfavourable to health, on account of the effect of the burning candles on the atmosphere in the carriages, but if they are ventilated properly, this will not amount to much.—*Bulletin du Musée de l' Industrie de Belgique, Sept. 1876.*

TOOLS AND THEIR USES.

BY PROF. J. E. SWEET.*

IN writing this series of papers on tools I ought perhaps to begin with those for wood-working; but as the iron-working tools more nearly concern us at present I will first speak of them, leaving the wood-working ones for an appendix, should our success justify it.

The first tools we have to deal with are the hand tools, principal among them the hammer, chisel, file and wrench. These, although of late largely superseded by machine tools, are by no means dispensable; and the workman who can handle them deftly can command better pay than he who can not; besides it is one of the first things which an employer or foreman notices in a new workman when judging of his ability. It is much cheaper to buy a good hammer, now that they are manufactured and in the market, than to make one; still some prefer to make their own, and there are one or two facts worth knowing.

It is not of as much importance whether the eye is an oval or a rounded slot, as it is that the eye is largest at the outside, curving in toward the centre and curving out on the opposite side as in Fig. 1. With an eye of this form the part of the handle entering may be left considerably larger than the eye and yet forced in. The wedges on the opposite side expanding the wood, give a far more secure hold than is possible to get otherwise. The handle should be left larger and smaller at the points shown

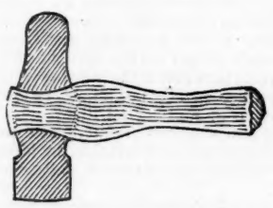


Fig. 1.

in Fig. 1—the first to prevent its being driven through the eye, and the second to give it elasticity. There is another advantage in using a trade hammer rather than one of your own make—you are likely to think more of your own than of any other, and make a practice of using it exclusively, so that if in case of emergency you have to use another, it seems awkward to you.

Better skill yourselves in striking with all kinds of hammers and in all positions; for to get the best and most varied experience, each of you must make a sort of universal machine of himself; you must be able to strike lying on your backs or standing on your heads; right hand or left hand, and with anything that best serves the purpose. It is not, as a general thing, policy to use a monkey-wrench to pound with; but it would be economy to spoil a monkey-wrench worth fifty cents, if it answered the purpose, rather than to spend a dollar's worth of time in going for a hammer,—although very poor economy if you could get a hammer for a quarter. In using the hammer the beginner always holds the handle in his hand with a firm grip; the experienced workman never.

*Read before the Mech. Eng. Association of the Cornell University.

Cold chisels, that is chisels for cutting metal, are of various forms and sizes, suited to different kinds of work; but the majority are known as flat, cape and round nose— the first wide for flat surfaces, the second, thin and deep for cutting channels and mortices, and the third similar to the second, but with one side rounded to chip out holes, curved corners, etc. In tempering they are first hardened and then partially softened by heating them until the colour of the bright surface turns purple blue. After grinding, the edge should always be ground square off—a little on the very smallest ones, and more on those used for heavy work. The edge, if left sharp, will either turn over and make the chisel slip, or it will break or crumble off; and when it breaks it does so higher up than it would have stood if ground off in the first place.

I will attempt to say but little in the way of files, except that each should have a well fitted handle; and for a given purpose I know of nothing more utterly unsuited than the tangs or shanks of files as universally made. By remodelling the tangs of our entire lot of files, I hope, during the term, to show and convince you that there is a good form as well as a bad one; although I feel sure that a quarter of a century at least will be required, (our graduates holding prominent positions,) before a general move can be made to change the wrong from the right. As they are now made, they are expensive to forge by hand, and very difficult to forge by machinery. There is no tool by which a proper hole can be made in the handle; nor can there, while they are of all sizes and degrees of taper, be such a tool made. Besides the tangs will not, even if put in in the best manner, stay in a handle as they should. There is no more sense or economy in changing a file handle every time one wants to change a file, than there would be in so changing a hammer handle; and if the tangs were of such form that when a handle was put on it would stay, workmen would no more think of shifting the one than changing the other. That part of the tang next the file where the handle is protected by the ferule, should be tapering to give it strength, is all right; but that the part back of the ferule, should be parallel, or nearly so, and of such size that it will drive tightly within a standard sized hole, is in my opinion the true form; as shown in Fig. 2, the handle, to be used

Fig. 2.

a long time without cramping the hand, should have a good deal of convex surface and very little, if any, concave; and there should be no beads or ornaments. The wood from which they are made should be thoroughly seasoned, or the ferules threaded on as a nut is screwed upon a bolt. Gas pipe, threaded on the inside and cut into short lengths, makes durable ferules. Files are cut their whole length; and to use only a small portion in the centre sacrifices half their value. The best practice is to run them their entire length at each stroke, running them at a steady uniform speed—not too fast; and to exert sufficient pressure to make them cut from end to end. If a file is run too fast, or allowed to slip over, it wears away the teeth; a pretty well worn file will cut if held to the work with sufficient pressure; and for steel (unless the file is made specially for it, with obtuse teeth,) it will endure more if used first on softer metal. The teeth of a new file are rapidly broken off, unless used with care.

The diversified practice of years ago, and the bungling attempt to establish a uniform system of sizes for the outside diameter of bolt heads and nuts, has so filled our shops with these bolt heads and nuts of all conceivable sizes, that to get along without the monkey-wrench would be impossible; and were a simple system in universal use it would still be a desirable tool for jobbing purposes. There are many good patterns in the market; none quite perfect and none half well enough made. They should be made entirely of the best tool steel, except perhaps the handle, and I am not sure but that ought to be a metal shell. A great defect in all of them is the lost motion. This can only be remedied by using enduring steel instead of yielding iron. Most wrenches will stand the strongest man's use if they are *set up tightly* to a square or hexagon nut and used the right way; that is, with the open end of the jaws toward you when pulling, or from you when pushing. But, owing to the slack motion in the screw, they are not always set up tight, and besides it is not possible always to use them the right way. Often, nuts are so located in a flanged corner that it is impossible to turn them with a monkey-wrench without holding the wrench wrong; it is in this way that they are over-strained, bent and often ruined. Always use the wrench the right way when you can, and the wrong way only when you must.

The time may come when some of you will wish to embark in business, and may question what this shall be. Unless the field is supplied before, I have faith that files equal to the best made in other respects, and with tangs of the proper form, can command the market. A good tang will not sell a poor file, but would advertise and create a demand for a good one. He who manufactures of the best tool steel monkey-wrenches of unexceptionable design, with workmanship equal to the best gun work, can build for himself as good a business and as great a reputation as Madole made for himself in the manufacture of cast steel hammers. It needs no invention or patent; any one of the old standard patterns fills the bill; but the very best stock, the use of the most perfect tools for forging and finishing, absolute honesty in the manufacture and sales, and business energy, will certainly succeed. The cost of these steel wrenches, at the most, can not be over twice the cost of iron ones; and it is just as unreasonable to say people would not pay a dollar and a-half for a steel wrench when they can get an iron one for half a dollar, as it would be to say that they would never pay a dollar and a-half for a steel rule when they can get a boxwood one for a "quarter." Solid wrenches should always be used on finished nuts; and had not the Philadelphia tool makers adopted one size and the United States Government adopted another which is used by the Eastern tool makers, we could get along with fewer numbers than we are now compelled to have. If the common solid wrench were a perfect fit, then the nuts would need to be absolutely of the same size; and, owing to the impossibility of so making them of case-hardened iron, it is necessary for the wrench to be a little loose, and this brings the strain wholly on the corners. To obviate this, I have devised the wrench, Fig. 3, which we use on our engine,

Fig. 3.

and which is the only one I have seen that will fit a nut perfectly, and yet go on easy; but the great objection to these wrenches is, that a person unaccustomed to their use is sure to turn them the wrong way. Though I designed and made a few of these ten years ago, it is only within the last three months that a plan occurred to me to overcome this defect by making the edge of the handle that is to take the pull round and smooth, and the other edge sharp. The workman will not be liable to do serious harm to either the nut or the wrench by turning backwards.

I ought to refer to taps, dies, and reamers, our standard tools, calipers, scrapers, &c.; but as on most of these things I have had much to say heretofore, and as I shall have occasion to mention the others as I proceed, I will turn to *Machine Tools;* and will begin my next paper with the most indispensable of all.—*The Polytechnic Review (Philadelphia).*

HOW TO USE LEATHER BELTING FOR MACHINERY.

MR. E. H. DAVIES, an experienced mechanical engineer offers some practical suggestions with regard to the employment of mill-banding or belting. He finds a first class leather belt will do three or four times the service of the best rubber belt that is found in the market. There is no economy in using a rubber belt at any price, unless it be where there is great heat or dampness. Leather belts should be thoroughly oiled before using. A good way to apply the oil, where there is much belting to be oiled, is to have the belting run off from one reel to another through a pot of oil, with suitable rubbers to wipe off the superabundance of oil. Another very good method of applying the oil—and perhaps it would be preferable in a majority of cases—is to put it on with a paint brush. This should be done on both sides, with no sparing hand. A belt thus oiled will not require a second application under ten years,

unless there be much dust to absorb the oil, and then it may be put on very sparingly compared with the first application. The advantages that an oiled belt has over a dry one are these: 1st, it lasts longer; 2nd, it requires less power to drive the machinery; and 3rd, it may be run much more slack, which makes the bearings less liable to heat, requiring less oil and less attention. There are but few people who pay any attention as to how they put on a cross belt, consequently they are just as likely to get it on wrong as right. There are but two ways to push such belts on. The right way is this; Put the belt on in such a manner that the driving pulley will have a tendency to rough up the splices; then when the splices come to the crossing they will smooth each other down instead of catching under each other's corners and tearing up a splice. A quarter twist belt should never be used where it can be avoided: but when it is used it should be as narrow as practicable, and the pulleys should be large. Increasing the width of a quarter twist belt does not increase its power in the same ratio as in a straight or cross belt. There is not more than one per cent. advantage in using an oiled belt with the grain side next to the pulley, which will hardly compensate for the ugly look which a belt presents when put on in that manner. In lacing a belt the lacing should never be crossed on either side. To lace a belt in this manner, there must be one more hole in one end than the other, consequently there will be a hole in the middle of one end, which is the place of beginning. Draw the lacing to its middle through this hole, lace each way to the edge and back to the middle again, and you have by far the nicest joint that can be put into a belt. No one will ever lace the old way after once getting "the hang" of this method. Plaited belts for engine governors and small machinery may be as scientifically laced, and the fastening will last as long as the lacing of a flat belt, with no more unevenness. The same authority shows how to determine the width of a belt to drive all kinds of machinery where power and speed are known. Rule: Place the number of horse power for a numerator, and the speed of the belt in hundreds of feet per minute for a denominator. That will give what the width of the belt should be in fractional parts of a foot.

A HISTORY OF THE BESSEMER MANUFACTURE IN AMERICA.*

THE memorable features of American history have been making fast progress during the last century, and notably so since 1860; and they are by no means confined to political or to any one branch of scientific development. Of all the industrial arts, none show a greater change or a mightier progress than the Bessemer manufacture. And this year, while we are celebrating the first Centennial of our national life, we can also celebrate the first decennial of American Bessemer practice. While not forgetting or undervaluing what has been done in other countries, I have thought that a brief history of the introduction and development of the pneumatic or Bessemer process in America would be of interest.

In 1863 the Kelly Pneumatic Process Company was formed, and an arrangement entered into with William Kelly, who had taken out Letters Patent of the United States, Nos. 16,444; 17,628 reissued as 505; 18,910, dated January 10, 1857; June 23, 1857; November 3, 1857; and December 22, 1857, respectively. This association was composed of the Cambria Iron Company, E. B. Ward, Park Brothers and Co., Lyon, Shorb, and Co., Z. S. Durfee, and later, Chouteau, Harrison and Valle joined the combination. Not satisfied with possessing the control of the Kelly patent, they sent Mr. Z. S. Durfee to England, to secure for this country Mushet's patent on recarburisation, No. 17,389, dated May 26, 1857, the same having been taken out in England, on September 22, 1856. In this Mr. Durfee was successful.

Previous to the application of William Kelly for a patent, Henry Bessemer, of England, had taken out patents dated February 12, 1856, and August 25, 1856, in this country. Kelly claimed priority in the discovery of the principles of the process, and the Patent Office allowed his claim by granting him his patents.

In the autumn of 1862, Mr. Alexander L. Holley, while in England, was impressed with the importance of Mr. Bessemer's invention, and so fully foresaw its future, that upon his return to the United States, he induced Messrs. John A. Griswold and John F. Winslow, of Troy, New York, to join him in endeavouring to possess Bessemer's American patents. Mr. Holley returned to England in the summer of 1863, but not until the spring of 1864 did he succeed in purchasing for Messrs Winslow, Griswold, and Holley, the desired right.

Thus, at about the same time there were two separate and distinct organisations seeking to control the future of the then undeveloped industry. While Mr. Durfee was abroad, his company determined to erect experimental works at Wyandotte, Michigan (where one of their members, Captain E. B. Ward, owned extensive iron works), with the view of testing the adaptability of American irons to the new process. Mr. William F. Durfee undertook the erection of the plant, and located it in the casting house of the Eureka blast furnace, intending to take the metal direct from the furnace. He put in a 2½ ton vessel with a long narrow casting pit, and arranged a system of rotary steam engines to hoist and pour the melted iron into the converter, and to rotate the latter. As Mr. Durfee was instructed to avoid as far as possible Bessemer's mechanical patents, he was very much hampered in designing his plans. But it was in these works in the fall of 1864, under the direction of Mr. W. F. Durfee, that the first pneumatic or Bessemer steel was made in America.

Mr. Z. S. Durfee brought with him on his return from England Mr. Lewellen M. Hart, who had acquired some experience in the business at the works of Messrs. Petin, Gaudet, and Co., in France. Upon the arrival of Mr. Hart at Wyandotte, he decided to build a reverberatory furnace for the purpose of melting the charges of iron, so as to be able to use a mixture of English and American irons, and it was from metal melted in this furnace that all the steel made by him at Wyandotte was produced. The works remained under this gentleman's charge until the beginning of 1865, when he severed his connection and went to Troy, New York, entering the service of Messrs. Winslow, Griswold, and Holley. He subsequently went to the Pennsylvania Steel Works at Harrisburg, Pennsylvania, and afterwards left their employ to engage in other business in Philadelphia, where he died.

In March, 1865, Mr. Ignatius Hahn assumed charge of the Wyandotte Works. This gentleman had lately arrived from Prussia, where he had been connected with the works of Krupp, at Essen. He conducted the works until July 4th, 1865, when he resigned his position. As Mr. Hahn's retirement left the company without any practical steel maker, and the works had thus far been conducted on an experimental basis, the proprietors determined upon making the most hazardous experiment of all, and put them in charge of the writer, who had gone there a few weeks before in the interest of the Cambria Iron Company. In accordance with this arrangement the writer made his first "blow" and by some strange fatality happened to "turn down" at just the right time.

In the fall of 1865 the reverberatory furnace was torn down, and thereafter, during the continuance of the works, the iron was taken direct from the blast furnace, excepting that which was melted with anthracite coal in a M'Kensie cupola, this was sent to the works to be tried experimentally, and which cupola having been put up by the writer during the summer of 1865. In October, 1865, the first heat of Bessemer steel made from Missouri Iron Mountain pig was blown by the writer, it having been melted in this cupola; the resulting steel was extremely satisfactory.

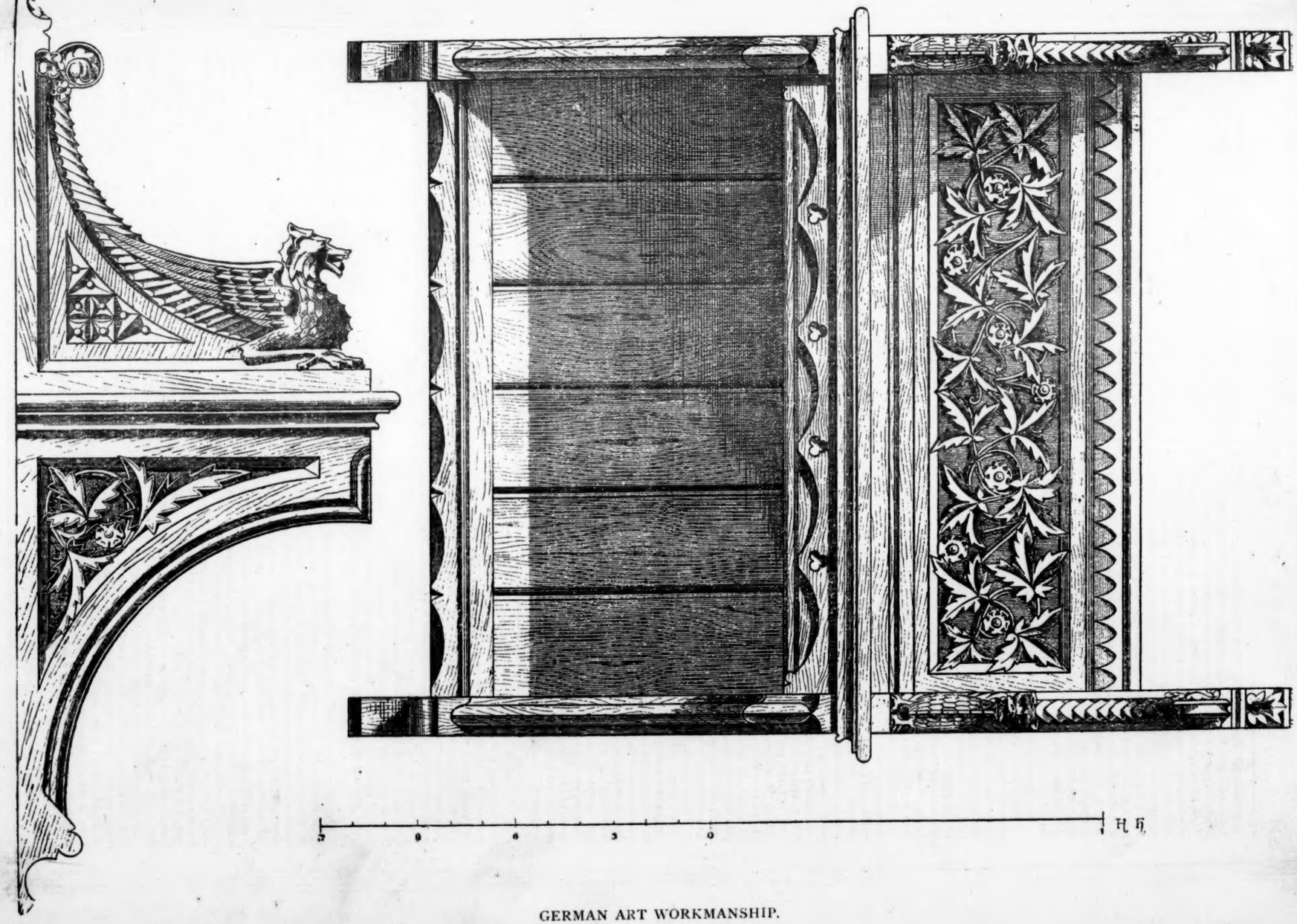
During Mr. Hahn's administration Mr. Z. S. Durfee made several attempts to convert iron melted in a small cupola of a foundry attached to the works, and located on the opposite side of the furnace casting house. But owing to the cupola being so distant and so small, thus requiring the iron to remain so long in the accumulating ladle, and then to be run so far in an open runner into another ladle and to be hoisted and poured into the converter—the iron containing also a low percentage of silicon—each trial was a failure. But I believe this was the first attempt to utilise the cupola as a melting furnace for the Bessemer process. At all events it certainly was the first time it was tried in America, and of its ultimate success Mr. Durfee was fully convinced. Mr. Holley must have been impressed at about the same time with the same idea, for the records of the Troy Works show that on July 20, 1865, the cupola was there used for the first time and with complete success.

The writer remained in charge of these works until May 14, 1866, when he turned them over to Mr. A. S. Aubrey and returned to the Cambria Works, that Company then intending to at once erect Bessemer works. During the year 1865 Captain Ward bought the works from the Kelly Progress Company, and they were thereafter conducted entirely in his interest, and after many alterations finally abandoned in 1869.

Upon Mr. A. L. Holley's return from England, in the spring of 1864, he at once commenced the erection of a 2½ ton

* A paper read before the American Institute of Mining Engineers at the Philadelphia meeting. By R. W. Hunt, Troy, New York.

XUM



GERMAN ART WORKMANSHIP.

experimental plant at Troy, New York, for the firm of Winslow, Griswold, and Holley, and started it February 16, 1865. While at the Wyandotte Works steel was made at an earlier date, the Troy establishment was the first to bring the process near to a commercial success. Not having been personally connected with these works during those early days, I cannot so fully realise the difficulties through which they passed, but I do know from the Wyandotte experience, to say nothing of any later experience, that it has required faith made perfect, to carry one through the sea which seemed to be bounded by no shores. As I have often expressed it, if we, knowing there was a way through all our troubles, felt so hopeless, what must have been Bessemer's pluck, to enable him to persevere through his difficulties, when the desired end was known only through faith?

But before entering into chronological details of subsequent works, I must here state, that after building the first experimental plant at Troy, Mr. Holley seems to have at once broken loose from the restraints of his foreign experience, and to have been impressed with the capabilities of the new process. The result is that mainly through his inventions and modifications of the plant we, in America, are to-day enabled to stand at the head of the world in respect of amount of product.

But to return to the detailed history. As before stated, there was in 1865 the two rival organisations claiming control of the process in this country—the Kelly Process Company, through their Kelly and Mushet's patents, and Messrs. Winslow, Griswold, and Holley, through their Bessemer and Holley American patents. Both parties felt strong in their respective positions and in possessing the necessary means to maintain them. But after spending large sums of money in counsel fees, they wisely concluded that their fight would at best be a "Kilkenny cat" affair, and so, early in 1866, they combined their respective interests, the Bessemer, or Winslow, Griswold, and Holley party taking 70 per cent., and the Kelly Process Company 30 per cent. of all royalties collected. To this wise compromise may we attribute the subsequent establishment of many works. Under this organisation, Messrs. John F. Winslow and John A. Griswold, of Troy, New York, and Daniel J Morrell, of Johnstown, Pennsylvania, were elected trustees, and they appointed Mr. Z. S. Durfee as their general agent.

But great difficulty was even yet experienced in inducing capitalists and manufacturers to attempt the introduction of the new manufacture. While the metal produced was wonderful in its qualities, still the necessary first outlay was so large, and the details of the process were so uncertain, and the time-honoured prejudice against anything new held such powerful sway, that our people hesitated, doubted, and waited. Wonderful tales came to us of what was being done abroad, and some venturesome railway managers even dared to import and place in their tracks trial lots of foreign Bessemer rails.

Messrs Winslow, Griswold, and Holley had, from the very first erection of their works, wisely pursued the plan of extending every facility to blast furnace owners, in all parts of the country, to have their irons tried for steel; and under this system many brands were tried and most were found wanting. These failures to obtain good results, of course built up still greater barriers against the spread of the process. In the light of our present chemical knowledge of the manufacture, it is amusing to think of firms sending a few tons of iron to Wyandotte, Troy, or even England, to be tried in actual practice, when a few hours of laboratory work would have settled the entire question. But still it was this very blind using of unknown irons that first opened the eyes of steel makers to the possibility of making good product from metals pronounced unfit by the then authorities.

The records of the Troy Steel Works show that on March 1, September 26, November 22, and November 30, 1864, trials of Wassaic, Copake, Fort Edward, Hudson, and Crown Point irons were made, in Henry Bessemer and Co.'s 1¼ ton vessel in Sheffield with the following result: Wassaic, "slopped over badly but hammered very well, very hard and not very ductile. Small ingot reheated when hot from mould, and crumbled under the hammer." Copake "slopped some, hammered tolerably well; harder and less ductile than Wassaic." Fort Edward and Hudson, "worthless and crumpled under the hammer." Crown point, first trial, "5 little sloppy, very ductile, pretty soft, no cracks;" second trial, "blew well with moderate blast, very good." The earlier of these were, undoubtedly, the first trials made of American irons.

In accordance, I presume, with these results, I find that the first conversion made at Troy was from Crown Point charcoal iron, the first at Wyandotte having been from Lake Superior charcoal, direct from the blast furnace. The success of the Troy Works, whenever good metal was used, encouraged the proprietors to commence the erection of new works on a more extended scale, and early in 1867 Mr. Holley completed the new or 5-ton plant, Mr. John C. Thompson then being superintendent of manufacture. Mr. Holley, at this date, assumed personal charge of the Pennsylvania Steel Works, having previously furnished plans for the machinery, and Mr. Thompson soon after took charge of the Cleveland Rolling Mill Company's Works. Mr. Z. S. Durfee then entered upon the management of the Troy Works. He built the forge, and made some alterations both in plant and details of manufacture. Among other things, he adopted for the small or experimental plant, the practice of melting the recarburising metal in crucibles, and obtained most excellent results. At this time the capacity of the works was stated to be 40 tons of ingots per day, but the records of the works fail to show any such actual results.

On October 16, 1868, the roof the five-ton plant at Troy caught fire, and was almost immediately consumed, destroying much of the machinery. Soon after Mr. Durfee resigned his connection with the works, and Mr. Holley once more became the manager, the property having been possessed by the firm of Messrs John A. Griswold and Co., Mr. John F. Winslow selling to them his interest. Upon rebuilding, Mr. Holley availed himself of his Harrisburg experience, and remodelled the works in a great degree, particularly as to the melting, or cupola house, and the blowing engines. The first blow was made in the rebuilt works on January 12, 1870. The small plant had been running most of the time, while the large works were being rebuilt. The ingots produced at these works up to January, 1871, had either been hammered in the forge or bloomed from 9 in. ingots at the Rensselaer Rail Mill and the Spuyten Duyvil Rail Mill, and then rolled into rails at these respective establishments. In January, 1871, Mr. Holley had a 30-in three-high blooming train ready to run, having located it in the forge; he used the hammer already there to cut and chip the blooms as they came from the rolls. The mill was provided, front and back, with lifting tables, containing loose rollers, and raised by hydraulic power. The rolls were turned to receive 12 in. ingots, which were cast heavy enough to make two-rail blooms. These ingots, after being placed on the rollers of the front table, were pushed into the rolls, both front and back, by hand; it requiring the power of eight men to operate the mill. The train was built with the top and bottom rolls stationary; the middle roll was moved up and down by four screws running through the bolsters which carry the necks of this roll, these screws being rotated by a friction clutch, which was driven by a belt off the main shaft of the mill engine, and reversed by a hand lever at the end of the rolls. This mill proved to be a great advance upon the old practice, and ran until the fall of 1872, when George Fritz's patent driven table rollers and pusher were added. By the use of these tables the force was reduced to four men, or rather three men and a boy.

The works continued steadily running after being rebuilt, Mr. Holley relinquishing the management in 1871, but still retaining a connection as consulting engineer, which position he still holds. He was succeeded by Mr. Barney Mee, who died February 11, 1872. His place was filled for a short time by Mr. John C. Thompson, who returned to the scenes of his first experiences, but his health failing the works were without a head until October 1, 1873, when the writer assumed control. Mr. J. Wool Griswold has been in direct charge since May 1, 1875. On March 1, 1875, the firm style was changed to "The Albany and Rensselaer Iron and Steel Company."

I must be permitted to mention, as an amusing incident, and as showing how little we can foretell what time will bring forth, that in 1865, while connected with the Wyandotte Works, I called, in passing through Troy, at the steel works, and presented a letter of introduction to Mr. Holley, who, in the gracious manner of which he is so capable, most blandly, but equally firmly, declined letting me inside the works, and with the best grace possible under the circumstances, I bowed myself out of his presence. Ten years later I am in charge of the works, proud to consider Mr. A. L. Holley my most intimate friend, and very careful to frequently remind him of our first interview. These works are now producing 1300 tons of ingots per week, which is sufficient to keep the rail mill running double turn. Their largest month gave a yield of 5498 gross tons.

The Pennsylvania Steel Works were the third Bessemer works started in the United States. The company was organised under the presidency of S. M. Felton, Esq., and under the auspices of such prominent railroad men and engineers as the late Edgar J. Thomson, Nathaniel Thayer, M. W. Baldwin and Co., William Sellers and Co., Bement and Dougherty, R. P. Parrott, H. R. Worthington, Merrick and Sons, Morris, Tasker, and Co., and others. Upon the first organisation of the company, Mr. William Butcher, of Sheffield, England, was elected as the engineer, and ground was broken, but, later, other

arrangements were made, and the works were built upon plans furnished by Mr. A. L. Holley, and on January 1, 1867, that gentleman severed his connection with the Troy Works, and removing to Harrisburg, assumed entire charge of the construction, being assisted by Mr. H. S. Nourse. In June, 1867, the Bessemer works were first started, and have been ever since in operation. The rail mill of the company not then being completed, most of the ingots were rolled into rails at the Cambria Ironworks, Johnstown, Pennsylvania, this arrangement lasting until May, 1868. I find it stated in an official publication of July 27, 1868, that the "annual capacity of the present Bessemer plant (two 5-ton converters) is about 10,000 tons, and of the rail mill 30,000 tons. Additional converters will be erected from time to time." The time for such additions has not yet arrived, but the product has been increased fully 500 per cent., the heaviest day up to date having been 281 ; week, 1291 ; and month, 5,455 gross tons.

The writer had charge of the rolling at Cambria of the Pennsylvania Steel Company's steel, and well remembers with what proud satisfaction Mr. Holley visited Johnstown and proclaimed to us all that at last his dream was realised ; that the Pensylvania Works were making four conversions on each turn, or eight per day, producing 40 tons of ingots. I presume that "official document" was inspired just about this time. In May, 1868, the rail mill was completed, and since then the company have taken care of their product at their own works. At first they pursued the same plan (rolling 8¼ in. ingots with a reheat) under which their steel had been rolled at Cambria, but subsequently introduced hammering ; two hammers have up to the present time drawn the ingots into rail blooms, but the company are now erecting a blooming mill constructed by Mr. James Moore, at Bush Hill Ironworks, Philadelphia.

Upon Mr. Holley's relinquishing the management of these works in 1868, he was succeeded by the joint-management of Mr. Nourse and Mr. John B. Pearse. This arrangement was in turn succeeded by another by which, in 1870, Mr. Pearse took charge of the company's business as general manager, Mr. Nourse remaining as superintendent. Mr. L. S. Bent is now in charge of the works.

The first ingots made at Harrisburg and sent to Johnstown to be put into rails were drawn into blooms under a 5-ton hammer. A limited number were also hammered at the works of Seyfert, M'Manus and Co., Reading, and the blooms sent to Cambria. While watching the behaviour of the steel under the hammer, Mr. George Fritz, chief engineer of the Cambria Works, became convinced that it was not the proper manner of treating the material, and he and Mr. Holley had many consultations on the subject. Mr. Fritz at once turned up a set of blooming rolls which he placed in a 21-rail train, and Mr. Holley caused 8¼-in. ingots to be cast and sent him. These were drawn to 6½ in. square, then recharged and wash heated, and then rolled into rails. So well did this work, that Mr. Holley adopted it in the Penusylvania Steel Company's rail mill, which he was then building. After many discussions and consultations, he decided on his return to Troy to build the heavier blooming mill to which I have before referred.

The Freedom Iron and Steel Works, near Lowistown, Mifflin County, Pennsylvania, were the fourth Bessemer works, started in this country. They were organised under the presidency of Mr. John A. Wright, and absorbed the interests of the Logan Iron Company, which company had been successfully working for many years. Mr. Wright visited England, and made purchases of the most complete machinery there known, and with the exception of the blowing engine, which Messrs. I. P. Morriss and Towne, of Philadelphia, built, the works may be said to have been of English construction and arrangement. The company intended to manufacture principally boiler plates and tyres, but the plate mill, which was driven by a Ramsbottom reversing engine, was soon changed to a rail mill. The works were under the direction of Mr. R. H. Lee, and ran for about one year, when, owing principally to the unsuitableness of the company's irons for Bessemer steel, the works were stopped, and much of the machinery subsequently sold. Their first blow was made May 1, 1868.

The Cleveland Rolling Mill Company's Bessemer Works, situated at Newburg, six miles from Cleveland, were the fifth works erected. These were built after the same general plans as the Pennsylvania Works, but Mr. H. Gmelin, the engineer in charge of construction, made many modifications. This gentleman returned to Austria before the blowing in of the works, which task was assumed by Mr. John C. Thompson, he making the first blow on or about October 15, 1868. Mr. Thompson soon resigned the charge owing to failing health, and the works have since then been conducted by Mr. Chisholm. In a short time, a second pair of 5-ton vessels were erected, and all four remained in operation until 1875, when the latter pair were removed to make way for Siemens-Martin furnaces, which are now running.

This company deserves credit as being the first parties in this country to make a commercial success of the application of Bessemer steel to wire, screws, and several other specialties.

The Cambria Iron Company, of Johnstown, Pennsylvania, were the sixth parties to build Bessemer works, their first blow being made by the writer on July 10th, 1871. As stated, the Cambria Iron Company did not erect Bessemer works until after five other concerns had started theirs, but nevertheless they were the very first corporation to give encouragement to attempts to perfect the new process.

When Mr. Kelly turned his attention to endeavours to shorten the process of refining iron by blasts of air, he was part proprietor and manager of a blast furnace at Eddysville, Kentucky. As in the case of many another seeker after the unknown, he spent all of his own money, and seriously embarrassed himself. It was about this time that Bessemer obtained his American patents. After filing his claims as the original discoverer, Mr. Kelly succeeded in interesting the Cambria Iron Company, and under their patronage he transferred his experiments to their works at Johnstown, in 1859, and there met with the usual number of discouraging failures.

The first Bessemer converter ever erected in America was built at Cambria by Mr. Kelly, and still remains there, a cherished relic. It was calculated to convert about half a ton of metal, and received its blast from the foundry blowing engine. But I never heard even a tradition of a perfect conversion made in this vessel. Still the Cambria Company, and more particularly its general manager, the Hon. Daniel J. Morrell, were impressed with the possibility of success, and when the Kelly Process Association was organised the Cambria Company were among the most earnest members. But the conservatism of other members of the company prevailed, and they did not complete their Bessemer works until 1871.

The chief engineer of the Cambria Works, Mr. George Fritz, had been personally familiar with all of Mr. Kelly's experiments, and had closely watched the progress of the process as developed by Bessemer and others, and during the time the steel made at the Pennsylvania Steel Works was rolled at Cambria he had abundant opportunities of studying the manufacture in its various mechanical details, and fully realise the advantages of the innovations introduced in the arrangement and details of Bessemer plant by Mr. Holley. These two gentlemen had been thrown, during this time, into the closest personal intercourse, and while Mr. Fritz was only too happy to assist Mr. Holley with his advice and large experience in perfecting the plans of the rail mill for the Pennsylvania Works, he was equally willing to avail himself of the latter's experience and advice in arranging his plans for the Cambria Bessemer plant.

But George Fritz could not blindly copy, and while cheerfully acknowledging everything taken from Mr. Holley, he introduced many new ideas in his arrangement of plant. He built vertical disconnected blowing engines, and arranged his converting building under one roof, without any dividing wall between the melting and casting houses. And when he came to the blooming mill he introduced the entirely new features of driven rollers in the tables, and a hydraulic pusher for turning over and moving the ingots on the tables. These two features constitute the Fritz blooming mill patent, now used by most of the Bessemer works of this country. The merits of rolling as compared with hammering had been fully discussed between Mr. Fritz and Mr. Holley, and they had, at various times, gone over the numerous details of a blooming mill, and Mr. Holley, as already stated, had built one at the Troy Works. Mr. Fritz had availed himself of the benefit of the extensive knowledge and sound judgment of his brother, Mr. John Fritz, of Bethlehem, Pa., and the result of all was the Johnstown Blooming Mill, which marked a new era in the Bessemer manufacture. While living to see many difficulties overcome, and great progress made, George Fritz died too soon, his country losing one of her noblest and ablest sons. He died August 5th, 1873.

The writer remained in charge of the works until September, 1873, when he went to Troy and was succeeded by Mr. John E. Fry, who is still in charge. The greatest yield at these works has been as follows: March 21, 1876, 297 gross tons in 24 hours ; week ending May 20, 1876, 1475 gross tons ; month ending March, 1876, 6051 gross tons.

The seventh works to go into operation, the Union Iron Company, are owned by the same parties who controlled the Cleveland Works, and are located at Bridgeport, or South Chicago, Illinois. Their first blow was made on July 26, 1871,

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and the works have been in almost constant operation ever since. They contain two 5-ton vessels, and the general arrangement is similar to the Newburg plant.

The North Chicago Rolling Mill Company, of Chicago, Illinois, built and started the eight Bessemer works. Captain E. B. Ward, of Detroit, was one of the heaviest owners in this company, and he, as before stated, had owned the Wyandotte Works, and was fully convinced of the merits of the process, and while abandoning the last-named establishment, took steps to have a larger and more complete plant erected in Chicago in connection with the extensive iron works of the company. Mr. A. L. Holley was engaged to furnish the plans, and the works were erected under the direction of Mr. O. W. Potter, then the general superintendent of the company. Mr. Holley, profiting by the experience acquired in building the several other works with which he had been connected, and by the already advanced state of the art, introduced many improvements in the arrangement of this plant, and when completed it was undoubtedly the most perfect in existence. The first blow was made on April 10, 1872, under the direction of Mr. Robert Forsyth, who had received his Bessemer education at the Troy Works. This gentleman has ever since remained in charge of the converting works, and has been most eminently successful in his management. His works are to-day making the largest output product of any in the world. The plant contains two 5-ton vessels. I might here say that while all the present American plants are said to consist of two 5-ton converters—the general practice is to convert nearer 6 tons in them. The ingots are bloomed in a three-high 30-in. mill with the Fritz tables.

The records of the North Chicago Company show their largest product for 24 hours to have been 330¼ gross tons; for one week 1583 gross tons; and for one month 6457 gross tons.

The Joliet Iron and Steel Company, having rolling mills at Joliet, Illinois, and blast furnaces at Chicago, determined to erect the ninth Bessemer plant in connection with their Joliet works. They purchased of the Freedom Steel Company their blowing engine, converters, hydraulic cranes, &c. Mr. Holley was engaged to furnish the plans, and the works were built under his general direction, Mr. A. L. Rothman and Mr. P. Barnes being the engineers in direct charge. The converting plant consists of two 5-ton vessels, and the blooming train is similar to that of North Chicago. The general arrangement of the two converting works is also very similar. The first blow was made on March 13th, 1873, under the direction of Mr. Dunning, who still remains in charge of the works. Their records show the greatest product in 24 hours to have been 350 gross tons; in one week 1528 gross tons; and in one month 5367 gross tons.

The tenth Bessemer plant was built by Mr. John Fritz for the Bethlehem Iron Company, of Bethlehem, Pennsylvania, and of which he was, and is, general superintendent and chief engineer, Mr. Holley being connected with him as consulting engineer. Mr. Fritz had studied the various American plants, and also visited England and the Continent, and after mature deliberation concluded to take a new departure. He arranged his melting house, engine-room, converting room, blooming and rail mills, all in one grand building, under one roof, and without any partition walls. He placed his cupolas on the ground and hoisted the melted iron on a hydraulic lift, and then poured it into the converters. The spiegel is melted in a Siemens furnace, also on the ground floor, and the melted spiegel is also hoisted and poured into the vessels.

The blooming train has the middle roll stationary, the same as the Cambria mill, the top and bottom rolls screwing up and down. Instead of depending upon friction to drive the rollers of the tables, Mr. Fritz put in a pair of small reversing engines. This feature has been adopted in a method which dispenses with belts, by means of a direct connection of the engines with the table, as arranged by Mr. Holley, in several of the other works. The works made their first blow on October 4, 1873, under the charge of Mr. Owen Leibert, who is still the superintendent. The highest product has been 264 gross tons in 24 hours; 1340 gross tons in a week, and 5282 gross tons in one month.

The Edgar Thomson Steel Company, limited, of Pittsburgh, Pennsylvania, were the eleventh parties to enter the business, locating their works at M'Kenney's, now called Bessemer Station, on the Pennsylvania Railroad, about nine miles from Pittsburgh; Mr. Holley furnishing the plans and Mr. P. Barnes being the resident engineer, he having severed his connection with the Joliet Works. In the fall of 1873, Mr. Wm. R. Jones, who had been George Fritz's assistant at Cambria, became connected with the Edgar Thomson Company, and upon the starting of the works in August, 1875, assumed charge of them. He is now the general superintendent of the company. Their largest product for 24 hours has been 265 gross tons; largest for a month's work, 5403 gross tons.

In arranging these works, Mr. Holley made many improvements over any of his previous efforts; and assisted as he was, the works stand to-day as a fit monument of the progress of the Bessemer process in this country.

The twelfth and last works to start were those of the Lackawanna Iron and Coal Company, of Scranton, Pennsylvania, being added to their already large iron plant. The converting works were built by Mr. A. L. Rothman, Mr. Holley acting as consulting engineer. The former gentleman started the works on October 23, 1875, and remained in charge until May, 1876, when he was succeeded by Mr. George F. Wilhour, who obtained his Bessemer experience at Johnstown, Pennsylvania. The blooming mill was built from Mr. Holley's plans, under the supervision of Mr. W. W. Scranton, the general superintendent of the company, and has all the late improvements.

The Vulcan Iron Company, of St. Louis, Mobile, have their converting works and blooming mill nearly ready to start, they being an addition to their already large iron rail mill and extensive blast furnaces. Mr. Holley has furnished the plans, and Mr. D. E. Garrison, the general manager of the company, has had immediate charge of the erection, Mr. John Hogan being his assistant. When these works start, there will be in operation eleven 5-ton plants with 22 vessels, capable of turning out, in the aggregate, 550,000 gross tons of ingots per year.

Having enumerated the various Bessemer works according to the order in which they started, and in so doing having referred to the wonderful increase in product, it seems a fitting conclusion to briefly review the causes of such wonderful strides in capacity. As stated, after building the original experimental plant at Troy, Mr. A. L. Holley seems to have appreciated that the manufacture was capable of a development far beyond any which had been attained in those countries in which it was already considered a success.

Even if his mind did not fully realise this conclusion, his mechanical intuition was alive to the possibilities of improvement, and the result of his thought gave us the present accepted type of American Bessemer plant. He did away with the English deep pit, and raised the vessels so as to get working space under them on the ground-floor; he substituted top-supported hydraulic cranes for the more expensive counter-weighted English ones, and put three ingot cranes around the pit instead of two, and thereby obtained greater area of power. He changed the location of the vessels as related to the pit and melting house. He modified the ladle crane, and worked all the cranes and the vessels from a single point; he substituted cupolas for reverberatory furnaces; and last, but by no means least, introduced the intermediate or accumulative ladle, which is placed on scales, and thus insures accuracy of operation by rendering possible the weighing of each charge of melted iron, before pouring it into the converter. These points cover the radical features of his innovation. After building such a plant, he began to meet the difficulties of details in manufacture, among the most serious of which was the short duration of the vessel bottoms, and the time required to cool off the vessels to a point at which it was possible for workmen to enter and make new bottoms. After many experiments, the result was the Holley vessel bottom, which, either in its form as patented, or in a modification of it, as now used in all American works, has rendered possible, as much as any other one thing, the present immense production.

Then he tried many forms of cupolas at Troy, adopting in the original plant a changeable bottom, or section below the tuyeres, and developing this idea still further in the first 5-ton works; then later, at Harrisburg, assisting Mr. J. B. Pearse in developing the furnace to a point which rendered these many bottoms unnecessary, chiefly by deepening the bottom and enlarging the tuyere area. Upon his rebuilding the Troy Works after their destruction by fire, Mr. Holley put in the perfected cupolas. At this time the practice was to run a cupola for a turn's melting, which had reached eight heats or 40 tons of steel, and then dropping its bottom. This was already an increase of 100 per cent. over his boast about the same amount in 24 hours.

The Cambria works were now running, and Mr. Holley had become officially connected with them as consulting Bessemer engineer. Many discussions and consultations took place between George Fritz, Mr. Holley, and the writer, as to the possibility of increasing the product of the works. Among other things, tapping cinder from the cupolas was thought of, and decided upon. These works had already placed their turn's work at nine instead of eight heats. The Pennsylvania Works, under Mr. J. B. Pearse's management, followed with an increased production. The Cambria Works applied the cinder tap, and the production went up to the unanticipated amount

of 30 heats, or 150 tons in 24 hours. Grand as we thought this, it is only about one-half of the present yield of each of several works. During all this time many details were modified, and as the new ways proved successful they were adopted into the regular practice. I think one thing which had a strong bearing on the increased production was the labour organisation of the Cambria Works. In compliance with the policy decided upon, I started the converting works without a single man who had ever seen the outside of a Bessemer works, and, with a very few exceptions, they were not even skilled rolling-mill men, but on the contrary were selected from intelligent labourers. The result was that we had willing pupils with no prejudices, and without any reminiscenes of what they had done in the old country, or at any other works. Of course when one works went ahead, the others had to follow. Mr. George Fritz was the embodiment of push; and with such men to call on as William R. Jones, J. E. Fry, Charles Kennedy, Alexander Hamilton, and D. N. Jones, his efforts were ably seconded, and Cambria for a long time maintained the lead.

Mr. Z. S. Durfee tried at Wyandotte to fill an ingot mould from the bottom, the steel being poured into the top of an adjoining mould. Upon taking charge of the works, I still further carried out this idea, and later Mr. John E. Fry and myself took out a patent on the process. At about the same time Mr Holley, at Troy, was elaborating the same idea, and later, at Harrisburg, carried it much further and patented it. After the starting of the Cambria Works, the process of bottom casting was fully gone into, and Mr. William R. Jones' improvements, since patented by him, rendered it a complete success. I know that some makers do not fully acknowledge its merits, but it certainly has a right to rank among the prominent features of the American Bessemer practice.

While I am not able to mention all the very many good things accomplished by the gentlemen at each and all the various works, I am, at the same time, well aware they have all done their share towards achieving the great end; and, fortunately, their respective relations have been so pleasant, that each one's experiences have been freely imparted to the others. This has done wonders to advance the science. But without one element, all skill and all mechanical talent would have been wasted, and with it nearly all things have been possible. That element has been, and is—"American push."

INFUSORIAL EARTH AND ITS USES.*

GEOLOGISTS have long since established, beyond peradventure, the fact that there are rocks in the interior of continents, at various depths in the earth, and at great heights above the sea, which are almost entirely made up of the remains of what were once living organisms. Such rock-masses, says Lyell, may be compared with modern oyster beds and coral reefs, and, like them, their rate of increase must have been extremely gradual. But there are a variety of mineral deposits that are now proved to have been derived from plants and animals, of which the organic origin was not suspected even by naturalists. Great surprise was therefore manifested when the late Prof. Ehrenberg announced the discovery that a certain kind of siliceous stone, called tripoli, was entirely composed of the remains of countless millions of extremely minute organic beings. This observation of the famous German microscopist speedily led to the discovery of the fact that deposits of this character were quite abundant, and that they were even being formed at the present time over extended areas. The minute organisms, whose skeletons make up the bulk of the deposits, which are now known under the name of infusorial earth, have been shown to inhabit the ocean in inconceivable numbers, giving rise to the luminosity of the waters, which has been the subject of much discussion, and flourishing in almost every place where water stands for several months of the year. Their indestructible shells are therefore to be found in greater or less quantity in the sedimentary deposits of all our bogs, ponds, and slow streams. They are found in great abundance beneath peat bogs, where they constitute strata, often many feet in thickness and of great extent, almost entirely composed of the siliceous carapaces of organic beings, so inconceivably minute that millions of their remains are found in a single inch. Ehrenberg estimates that about 18,000 cubic feet of these siliceous organisms accumulate annually in the harbour of Wismar, in the Baltic. He has, furthermore, demonstrated that they accumulate in the beds of American and other seas, lakes, and rivers.

* By Dr. W. H. Wahl, Editor *Polytechnic Review*, Phila.

The deep sea soundings which have lately been conducted in various quarters of the world, and have attracted much popular interest, have shown, likewise, that the impalpable mud or ooze, which is accumulating at great depth in the bed of the Atlantic and other oceans, is made up almost entirely of the mineral skeletons of certain extremely minute organisms. Of these shells, some are calcareous, and appear to be identical with the organisms which abound in the chalk of Europe—the chalk, indeed, is largely made up of such organic remains—while others are siliceous. One of these deposits in the North Atlantic has been traced over a distance of thirteen hundred miles in breadth, and not less than six hundred miles in length.

In peat bogs, swamps, and the like, both of modern and ancient origin, there are often found layers, at times many feet in thickness, and of considerable extent, of a white siliceous paste, which is found beneath the microscope to be made up wholly of the remains of these minute organisms. These deposits, with which this article is chiefly concerned, are designated by geologists with the name of infusorial earth. The substance of which they are composed has generally, when dry, the appearance and consistence of friable chalk, and the remains of which it is made up, and which were formerly referred to microscopic infusoria, are now generally held to be plants, called by naturalists *diatomaceæ*. The remains of these diatomaceæ are of pure silex, and their shapes, as seen beneath the microscope, are various, and form objects, often of extreme beauty. These forms are very marked and constant in particular genera and species, of which many hundreds have been described and classified by Ehrenberg, Bailey, and others, and while many of the fossil forms are identical with living species, others are allied to them; and the so-called infusorial beds are sometimes of marine and sometimes of fresh water origin. The infusorial earth may readily be distinguished from the several calcareous and clayey deposits, which it resembles in appearance, by the fact that it does not effervesce in acids, and its ready solubility in solution of caustic soda or potash. It has long been well known in the arts as a powder for polishing stones and metals. At Bilin, in Bohemia, which is famous for its occurrence, there is a single stratum of this material, not less in some places than 18 feet in thickness, and extending over a large area. This stone, when seen beneath the microscope, is found to consist of the siliceous plates or frustules of the above mentioned diatomaceæ, united together without visible cement, and so inconceivably minute are the particles of which it is composed that, according to Ehrenberg's statement, a single cubic inch, which weighs about 220 grains, contains about 41,000,000,000 of individuals, and a single grain no less than 187,000,000. Other deposits of infusorial earth (kieselguhr), scarcely less extensive, occur in Germany, at Berlin, and at Planitz, in Saxony. It is found near Lüneburg, in a stratum nearly 28 feet in thickness, and again at Kliecken, near Dessau, and in the vicinity of Cassel. In England deposits of considerable magnitude have been found in Surrey, at the base of the chalk hills, and elsewhere. In Ireland there is a celebrated stratum on the banks of the River Bann, in the county of Down, and which, from being in much request for polishing plate, is locally known as Lord Roden's plate powder; another bed is found at the base of the Mourne Mountains, in the same county. In Lapland a similar earth is met with, which in times of scarcity, it is said, is mixed by the inhabitants with the ground bark of trees and used for food. The edible earth of Lillhaggsjon, in Sweden, is of the same nature. The infusorial earth is found in quantity in the Isle of France and at San Fiora, in Tuscany, and deposits of various thicknesses have been detected in Africa (the tripoli of commerce is an infusorial earth that has long been exported from the country whose name it bears), Asia, Australia, and New Zealand. In America it has been found in a great number of localities, and occasionally in enormous quantities. Of this nature are the beds of white earth along the banks of the Amazon, in Brazil, and used occasionally as food (?) by the native inhabitants. They have been detected also in Newfoundland and Labrador. In the United States, perhaps the most remarkable is that upon which the city of Richmond, Va., is built. This deposit is, in places, over 20 feet in thickness, and has been traced by Prof. W. B. Rogers, who was the first to point out its nature, from Herring's Bay, on the Chesapeake, Md., to Petersburg, Va., and beyond. At Petersburg the stratum is 30 feet in thickness. Beds of the same character and of some magnitude have likewise been found in California, Oregon, and other points on the Pacific, and at West Point, N.Y.; while of less importance are the infusorial beds at Wrentham and Andover, Mass., Smithfield, R.I., Stratford, Conn., and other localities too numerous to mention.

An interesting occurrence of this nature is the deposit of infusorial earth at Drakeville, Morris County, New Jersey, and which, through the instrumentality of the writer and others,

was first brought into general public notice about three years ago. The bed in question is on the property of the late Frederick S. Cook, and is located at the foot of Schooley's Mountain. The annual report of Prof. George H. Cook, State Geologist of New Jersey for 1874, contained a descriptive article in reference thereto, from which we obtain the following statements concerning its probable extent, etc. :—

"It has been known as a white earth or marl for a long time, and some years since was dug out and spread upon the soil as a manure; it had also been observed to possess remarkable excellence for scouring silver. The establishment of a manufactory for making nitro-glycerine and giant powder at M'Cainsville, near Drakeville, in which infusorial earth imported from Germany was used, led to an examination of this deposit, when it was found to be the same material with that they were bringing from Europe. The deposit occurs in a depression of the surface just at the foot of the mountain (Schooley's). The swale appears to be occupied in its lowest part by a common swamp of low bushes, growing in wet black earth; but by digging in the black earth it is found to be only about a foot thick, and underneath it is the infusorial earth. The extent of the black ground is about 540 feet in length by 200 feet in breadth, and 100 yards north-east is another but much smaller deposit. A trial pit sunk in the middle of the swale showed a thickness of 12 inches of black earth, 8 inches of very light infusorial earth, and 12 inches or more of a much denser infusorial earth. The lower part is said to be 3 feet thick, but I only examined the upper foot of it."

The report continues: "There is little doubt that other deposits will be found in the small ponds and swamps in this gneiss region, and those interested will do well to make search for it in any of the swales where these little swamps occur. It can be easily reached by digging, and when found can be distinguished from any other white earth by its not effervescing with acids as white marl does, by its not becoming plastic when wet, as white clay does, and by its dissolving almost entirely in a strong boiling hot solution of washing soda.

"The importance of this material will be appreciated when it is stated that the manufacture of *dynamite*, or giant powder, at Drakeville, has reached 50,000 pounds a month. There are different grades of *dynamite*, but some of it contains 25 per cent. of infusorial earth."

An analysis of an average dried sample of the Drakeville deposit yielded the writer 47.12 per cent. of soluble silica.

Concerning the application of this curious substance in the useful arts quite a chapter might be written. During the past few years it has attracted the special attention of practical men, and so many and various have been the uses for which it has been suggested that their bare enumeration may well excite surprise. At least one very important industry of recent origin has been practically created by it, and its employment in others is steadily growing in extent and importance. A summary of the subject in its technical aspects, with brief comments upon the more important items, is given in what follows.

The most popularly known, and perhaps the earliest application of the diatomaceous earth, is its utilization as a polishing agent for stone and metals. For this purpose, when carefully freed from grit and other impurities, its considerable hardness and its wonderfully fine state of division fit it most admirably. It may be applied wet or dry. It is well known in this connection under the name of tripoli, so called from the locality whence it was originally brought. Under the name of "electro-silicon," "magic-brilliant," and other trade designations, the diatomaceous earth from Nevada and other localities have been extensively introduced as a polish for gold, silver, and plated ware, for which—as for tin, Britannia ware, and other metals used in the household—its wide popularity is the best proof of its excellence.

Being a very poor conductor of heat, it has been suggested and applied for surrounding ice, beer and ale cellars, fire-proof safes, steam-boilers, powder-magazines, refrigerators, etc. The results of certain experiments lately made by Refart & Co., of Braunschweig, to ascertain how this material compared with other substances generally employed for the purpose, are highly favourable to the merits of infusorial earth for this application.

Without entering into the mechanical details of the apparatus employed in these trials, it will suffice to state that in the time required to melt 100 parts (by weight) of ice surrounded by the siliceous earth, 235 parts of ice were melted in a cylinder surrounded with an equally thick layer of dry, light garden earth. Moist earth, and moist materials generally, gave still more unfavourable results. Again, for every 100 parts of ice melted when protected by the infusorial earth, 142 parts of ice protected by dry, sifted coal ashes, were melted. The results obtained with flax-shives were about the same as with the infusorial earth. These trials demonstrated that infusorial silica and flax-shives offer the greatest amount of resistance to the transmission of heat; that dry coal-ashes are far less efficient, and moist ashes still more so; and finally that earth, as compared with these, is very inferior as a non-conductor. The use of the infusorial earth is therefore highly recommended for filling in between the walls, and for covering the mason work in ice-cellars. For this purpose the following additional advantages are urged in favour of this substance, viz. :—It is extremely light—being nearly five times as light as dry earth, and about half the weight of dry coal ashes,—and it is not combustible, remaining unaffected in the hottest fire. These properties, to quote from the published account of the above trials, "render this substance preferable to flax-shives, tan-bark, peat, saw-dust, and similar materials, which are about equal to it in non-conducting quality, but which are combustible, and when kept for some time rot or moulder, shrink and settle, and might under some circumstances, take fire spontaneously" *(sic!)*.

The infusorial earth, it is further claimed, will be found highly useful in fire-proof safes, as a surrounding for powder-magazines on shipboard, for covering steam-pipes and boilers, and for all similar purposes. Reference is made in some of the encyclopædias *(vide* "American Encyclopædia," iii. 268) to what are termed floating bricks, which, according to account, are made of infusorial earth, and are named in virtue of their power of floating upon water. Clay is sometimes added to the silica to assist in binding the material together. Such bricks, we are told, were made in ancient times, and were described by Posidonius and Strabo, and particularly commended by Vitruvius, Pollio, and Pliny. In 1791 they were again brought into notice by Giovanni Fabroni, in Tuscany, who, after many trials, succeeded in making bricks which would float upon water. Their strength was but little inferior to that of ordinary bricks; they are remarkable not only for exteme lightness, but also for their infusibility, and for being very poor conductors of heat; they may be held at one end while the other is red-hot. As an experiment, Fabroni constructed the powder-magazine of a wooden ship with these bricks; the vessel being set on fire, sank without explosion of the powder. In 1832 Count de Nantes, and Fournet, a mining engineer, used them in constructing powder-magazines and other parts of ships, thus lessening danger from fire. From an earlier source ("Encyclopædia Americana," ii. 266) we are informed that these floating bricks, made of agaric mineral, or fossil farina,—the infusorial earth,—have been found, on account of their infusibility at the highest temperatures, to be extremely useful in constructing reverberatory furnaces, pyrometers, and magazines of combustible materials, while their lightness and non-conducting qualities render them particularly useful for the construction of powder-magazines on board of ships.

In agriculture, the use of the infusorial earth has been suggested as a manure for lands poor in silica, which substance enters importantly into the constitution of the stalks and outer coverings of cereals. Quite an animated controversy, indeed, has of late sprung up as to the merits of infusorial silica as a component of fertilizers, an idea which forms the essential feature of a patent lately issued to Messrs. N. & G. Popplein, Jun., of Baltimore. It would be foreign to the purpose of this sketch to enter into a discussion of the merits of this controversy, involving as it does the introduction of certain debatable questions in agricultural chemistry; but the ideas of the Messrs. Popplein have aroused on the one hand such warm championship, and on the other such opposition, that a concise statement of the points in dispute may not be amiss.

The manufacturers before named, proceeding from the well-known fact that the relative quantity of silica in the ash of the cereals is greatly in excess of what is required for the normal combination with the bases (potash, soda, etc.) found therein, claim that in the ordinary course of things it is impossible for Nature to furnish to cultivated lands for successive years the proper amount of silica in assimilable form for the plant, inasmuch as the liberation of this substance by the chemical decomposition of the mineral matters of the soil containing it, goes on so slowly as to render doubtful the production in many years of the amount required for a single crop. In proof of this assertion they refer to the great reduction in the yield of the wheat crop, since farmers began years ago to sell the straw of the crop that formerly was returned to the soil. For this, and other reasons less obvious, their attention was attracted to the importance of incorporating silica into commercial fertilizers—one difficulty remained to be overcome, namely, the discovery of a form of the silica—which should be assimilable by the plant. This they claim to have found in the infusorial earth,—in which the silica is in an inconceivably minute state of division,—the result of their consideration

being the production of a so-called "silicated superphosphate of lime," a superphosphate with which the infusorial earth is intimately incorporated. The argument urging the importance of an abundant supply of silicic acid in available form, as an absolute necessity for the proper nutrition of cereals, is not disputed; and the manufacturers, to demonstrate the availability of the silica in the form in which they employ it, affirm that they have succeeded in proving the highly interesting and novel fact that the very minute skeletons or shells of which the infusorial earth is mainly composed are carried up *as such* into the body of the plant itself. Upon this point the following gleanings from an investigation conducted by Prof. P. B. Wilson will be read with interest :—

This chemist subjected to a microscopical examination the straw from the wheat-fields of Col. J. B. Kunkel, of Fredrick County, Maryland, which had been fertilised by the silicated phosphate, his purpose being to make "a more complete investigation into the siliceous structure of the stalk, in determining whether the infusoria passed directly as such into the sap-cells, to be carried forward by capillary force, and to finally assume their functions, —the formation of the epidermal shield for giving strength to the straw, to withstand the destructive force of high winds and beating rains, as well as a protection against the attacks of parasites."

"In making these investigations thorough precautions were observed, to cleanse the straw from all accidental impurities by washing and gentle friction, not sufficient, however, to destroy the epidermis. The organic matter was then removed by the prescribed methods, aided by my own experience.

"My labours," he continues, "have been amply rewarded by one of the most enchanting views that has ever fallen to my lot to behold through twenty years of varied scientific investigations. When the epidermal siliceous coating was adjusted upon the field of the microscope, some thirty-six forms of the Diatomaceæ, which I have carefully sketched, were observed (see engraving, magnified 300 diameters) where perfect disintegration has been produced. When the structure to a great extent is retained, a marvellous interlacing of these forms presents itself sometimes side by side, at other times over-lapping."

From this very interesting observation, Prof. Wilson advances a number of inferences, which, although the writer is not prepared to accept in full, are of sufficient interest to warrant their reproduction. He affirms that his investigation "overthrows all theories that have ever been advanced, that silica enters into plant structure in combination with the alkalies, the alkaline earths, or the earths proper. Chemical investigation led me to this conclusion some months since, now confirmed by that of the microscope.

"My mind was particularly impressed with the absence of the disc-like form, the *Actinocyclus ehrenbergii* and the *Actinoptychus undulatus* in their perfect state in the straw, while the other forms are common both to the infusorial earth and the wheat. My conclusions are that the varieties mentioned are too large to enter the root capillaries, for on the field of the microscope they have three to four times the magnitude of the others. This I will fully investigate during the coming summer, by making accurate measurements of rootlets and diatoms, when I will be able to obtain stalks of wheat as grown in the fields, preferring this mode of investigation to *pot culture*, to disarm controversy, and to divest the investigation of all semblance to laboratory experiment.

"I have examined various specimens of wheat straw taken at random from the market, but have failed to find a single diatom. This to a certain extent surprised me, when taking into consideration that they are found to a limited extent in Peruvian guano. The inference to be drawn is, that the soil was not fertilized by any material into which it entered as a constituent. I mention this to guide others who may make subsequent investigations from falling into error, in case occasional Diatomaceæ are observed, as being derived from other sources than the infusorial deposits.

"These microscopic investigations show the absence of other forms of silica, that is, in granular particles in the (Kunkel) straw, they being entirely replaced by diatoms. This leads to the conclusion, that the diatom is the more acceptable for assimilation, and when sufficient infusorial remains are present, replaces any other divided form of silica. I have previously attempted to substitute silica for diatoms, as obtained from the decomposition of slags from iron furnaces, but we have failed to derive any satisfactory results. This is due to its combination as a silicate; and when liberated by stronger acids, it agglutinates into masses too hard and large to be absorbed by the plant."

Prof. Wilson concludes his report in the following glowing terms :—"I look upon this application of vegetable silica to fertilizing purposes as the most important adaptation of matter for the reproduction of vegetation that has ever been discovered. It is the first step in a new direction, rationally conceived and judiciously carried out. A new impetus will be given to the study of plant physiology, which will demonstrate that more than a heterogeneous mixture of elementary bodies and their compounds are required for the production of the crops beneficial to the requirements of man."

With regard to the foregoing statements and inferences of Prof. Wilson, while not attempting to undervalue their great interest and possible entire accuracy, the writer would remark that the demonstration of the presence of the infusorial forms in the structure of the wheat stalks proves simply that these bodies are sufficiently minute to enter the root capillaries and pass into the sap-cells of the plant—nothing more. It may possibly be that, once having entered the body of the plant, they are assimilated, and made to subserve to the function of giving strength to the stalk; or, as appears to the writer equally plausible, they may simply act as so many minute mechanical impurities drawn into the circulation of the plant, and effecting a lodgment wherever they chance, clog up the passages, and thus actually obstruct rather than serve the process of nutrition. To follow the history of one of these forms in a living plant under the microscope, and observe its gradual dissolution, would afford the only method of positively proving the truth or falsity of either of the explanations that have been presented. While not presuming to decide so doubtful a question, it is very reasonable to believe that much of the silica of the so-called silicated superphosphate is made "available" as plant-food in solution as an alkaline salt, in which condition its assimilation by the plant presents no difficulties to the understanding. Dr. Wolf, the excellent State Chemist of Delaware, has kindly furnished the writer the following record of an analysis of the "silicated superphosphate," viz. :—

Soluble Phosphoric Acid, . .	5·855 per cent.
Precipitated Phosphoric Acid, .	3·327 „
Insoluble Phosphoric Acid, . .	trace.
Silica, ...	20·568 „
Sulphate of Potassa, . . .	6·173 „

According to the Messrs. Popplein's published formula, the net ton of their "silicated superphosphate" contains :—

Infusorial Earth, ...	800 lbs.
Dissolved Bone, ...	800 „
Potash Salts, ...	400 „

As an absorbent and carrier of liquids of various kinds, and especially as a carrier of nitro-glycerine, the infusorial earth has been found to be most excellently adapted. It takes up from three to five times its weight of water, oil, nitro-glycerine, etc. It would doubtless prove equally valuable as a carrier of carbolic acid and other disinfectants, as a disinfecting powder, and has possibly already found application for this purpose.

In order to bring nitro-glycerine within the range of articles of transport, Nobel, who first demonstrated its value in the arts, devised the production of a powder now so extensively employed under the name of dynamite, in which the explosive oil is simply carried by the inert, pulverulent siliceous earth. The process of the preparation of dynamite may be described as follows :—

The infusorial earth must first be freed from water, organic substances, and mechanical impurities (sand, etc.) The first two are removed by calcining at a red heat in an oven with several shelves, one above the other, on which the earth is placed, and slowly pushed from the upper to the lower. The organic matter, which is considered dangerous to the stability of the dynamite, is thus burned out. It is then pressed with hard rollers and sifted, which separates it from the larger particles and grit. It is now ready for use.

Fifty pounds of infusorial earth are put into flat wooden tanks, and covered with 150 pounds of nitro-glycerine, when the workmen mix them with the naked hand. Gloves of India-rubber were at first provided, but the workmen preferred to knead the mixture with the free hands. In half an hour the incorporation of the oil with the earth is complete, and the dynamite is ready for filling in the cartridge moulds. The cartridges are simple cylinders, protected by parchment paper. If ordinary paper is used the oil soaks into it, and there is great danger of premature explosion. Dynamite is a brownish grey, sometimes reddish, inodorous, pasty, greasy mass, having the specific gravity of 1·6. When ignited by an ordinary flame, it burns up quickly without detonation, and must therefore be fired with a patent exploder containing fulminate of silver inclosed in a copper capsule. It requires a heavy blow of a hammer on an anvil to explode it, and even then only the portions struck

are fired. In this respect it presents great advantages over nitro-glycerine, which is easily exploded by percussion. On the other hand, the wood of the boxes in which dynamite is packed becomes by slow degrees impregnated with nitro-glycerine, and forms a most dangerously explosive material, which may give rise to serious accidents in warehouses where it is stored. As long as the nitro-glycerine is confined in the infusorial silica, there appears to be very little danger, but the escape of a few drops of the oil may be the source of great mischief. The force exerted by the dynamite is much greater than that of gunpowder, and under the name of giant powder it has been largely employed in the mines of California. Other explosives, such as dualine and lithofracteur, may be said to be varieties of dynamite, having nitro-glycerine for their base, and using saw-dust or some other substance as an absorbent. All of them are powerful explosives, and must be handled with care.

For the preparation of cements and of artificial stone, a number of processes have been devised, in which infusorial earth plays a prominent part, viz.: Equal parts of infusorial silica and letharge, and one-half part of slaked lime, stirred into a paste in linseed oil, is affirmed to become as hard as sandstone on setting, and is recommended as an excellent compound for cementing stone, metal, and wood. The following recipe, again, is pronounced to be serviceable for the production of an artificial stone for art objects. For this purpose the infusorial earth is intimately mixed with well pulverized, freshly burned lime, in the proportion of from three to six parts of the former to one of the latter. The mixture is then pressed into moulds under an addition of a very slight quantity of water. The resulting product, a silicate of lime, is formed with the evolution of considerable heat. The objects produced ultimately attain great hardness; they are perfectly water-proof, and may readily be coloured with any colour used in stereochromy.

In combination with sulphur, infusorial earth forms a plastic mass, called zeiodelite, but no uses have yet been made of it.

By far the most important application of infusorial earth in this direction, however, has been successfully accomplished by Mr. Fred. Ransome, of England, in the production on the large scale of an artificial stone for general purposes, to which he has given the name of apoenite. The so-called "Ransome stone," invented by this gentleman, is made by thoroughly incorporating sand and silicate of soda in a mixing mill, moulding into the form required of the block, and then saturating the same with a solution of chloride of calcium, either by exhausting the air with air-pumps, or by forcing the solution through the moulded mass by gravitation or otherwise. The result is the formation of an insoluble silicate of lime, which firmly cements the particles of which the mass is composed, and of chloride of sodium or common salt, which is subsequently removed by the free application of water. The process of washing to remove all traces of the salt from the Ransome stone, which is necessary to prevent its efflorescence and secure its proper cementation, was found to be in many cases so tedious, expensive, and objectionable, that the inventor, after many experiments, devised the following process, in which the use of chloride of calcium is avoided. Mr. Ransome mixes suitable quantities of lime (or substances containing lime) and soluble silica (*i.e.*, infusorial earth) with sand, and a solution of silicate of soda or potassa, which, when intimately incorporated, are moulded as before, and allowed to harden gradually, as the silicate of lime produced by the action of the lime on the silicate of soda, is formed. As rapidly as the soda (or potash) of the water-glass solution is set free, it dissolves some of the infusorial silica, and again gives it up to the lime to form more cement, acting thus as the carrier of silica to the lime, until eventually all the lime is combined. In the course of the successive changes that take place, a portion of the free alkali appears to be bound at each step with the lime, as a compound silicate; and as the result of these several changes the whole of the alkali is gradually fixed, thus leaving nothing to be washed out. The mass gradually becomes thoroughly indurated, and in a very short time is converted into a very compact stone—apoenite—capable of withstanding enormous pressure, and increasing in strength and hardness with age.

In combination with magnesite (carbonate of magnesia) infusorial earth forms what is described as an excellent cement, which is manufactured in Germany, and sold under the name of "albolite."

In pottery the infusorial earth has received several important applications. When fused, for example, with borate of lime, as such is obtainable in the trade under the name of boronatrocalcite or tincalzite, an excellent glazing is produced (*Manufacturer and Builder*), which is not only useful for furnaces and pottery of all kinds, but also for enamelling iron and slate, being free from lead and not apt to crack off. By fusing a mixture of infusorial earth (freed from sand) with borate of magnesia (stassfurtite), a kind of "hot-cast porcelain" is produced, having great durability and beauty. For this purpose the infusorial earth requires to be perfectly dry and free from lumps. It is introduced into the crucible in small portions and under constant stirring, until the fused stassfurtite ceases to take up more. The mass may be cast like glass, and if very liquid may even be blown, and is thus fitted for an extensive application (*ibid.*).

Bœttger publishes the observation that when an alcoholic solution of any of the coal-tar colours is mixed with a sufficient quantity of infusorial earth, water added, and the mixture filtered, the liquid will run off clear, while the earth retains all the pigment. Hitherto, the compounds of alumina have been used for the production of the so-called lakes, and it is quite probable that the above-noted behaviour of this material may find important applications in the arts.

The use of infusorial earth has been suggested in glass making as a substitute for sand; but it appears not to be well suited for this purpose, the reason assigned being that it swells too much in the crucible. In the manufacture of soluble glass (water glass), for which it has likewise been tried, the impurities it contains—clay, phosphate of lime, etc.—have been found to render it somewhat unsuitable.

To conclude a sketch which has unwittingly taken considerable proportions, the following enumeration will suffice to show that the subject is by no means exhausted: A compound called diatite, devised by Merrick, consists of gum-lac and infusorial earth. The siliceous earth has been added to sealing-wax to prevent its running; it is sometimes added to paper to give it body; and to soap for the same purpose, and to add to its detergent qualities (?); and it is said to form an excellent addition to rubber, for certain uses of the latter; its addition to modelling clay is said to prevent it from cracking in moulding; and lastly, though doubtless many real or suggested applications of this curious substance have been overlooked, it is said to be of use in the manufacture of smalt and ultramarine.

Chemistry applied to the Arts, Manufactures, etc.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

NON-TRANSPARENT Varnish.—When oxidised silver articles require to be varnished—which could not till now be satisfactorily done for want of a suitable varnish—a recently-invented species of varnish is used, which produces a perfectly opaque, non-glistening coating. It consists of 18 parts of alcohol, 3 of red arsenic, and 1 of castor-oil, and may be diluted for especially fine coating of instruments, &c., with an equal quantity of alcohol.—*Stummer's Ingenieur, Nov., 1876.*

Etching of Glass.—Since fluor preparations have been produced at so moderate a price, the ornamentation of glass articles by etching has made great progress, so that really polished glass is now very rarely met with. It follows from the nature of things that ornaments produced by etching are artistically more beautiful, and technically more perfect, than those produced by polishing.

It is known that fluoric acid, if brought into contact with a glass surface, produces an etching which appears not frosted but glistening, because the attack on the part of the fluoric acid proceeds in a perfectly uniform manner. Other fluor preparations, on the contrary, produce a frosted surface, which is most beautiful, if the etching is performed with fluoride of ammonium, weakly acidulated with acetic acid. This frosting is, of course, varied according to the quality of the glass; and a more beautiful frosting is produced on lead glasses, which are much more easily attacked, than on other glass compounds.

If it is desired to etch the glass surface so as to be not uniformly frosted, but to present the appearance of a window-pane covered with ice, this may be accomplished easily by strewing the glass, laid horizontally, with a fine protecting powder, and pouring the diluted fluoric acid over it. The separate grains of this dust, which may consist of various substances not affected by the acid, prevent the action of the acid in the occupied

parts, and thus a glass surface is obtained which appears overspread with frosted points.—*Ibid.*

Export of English Railway Materials.—The value of the railway carriages exported from England in the course of last year was £134,803, against £111,069 in the preceding year. —*Ibid.*

Target-Shooting by Night.—Experiments were lately made at Sebastopol in shooting at targets during the night with the aid of peculiarly constructed rocket-light balls. They gave a perfectly satisfactory result, especially as far as the artillery came into play; but the infantry were less successful, because they thought the duration of the burning of the rockets too short, and hence hurried in firing. As, however, the light of the rockets lasted more than eight seconds, it was possible to fire even two well-aimed shots during that time.

The experiments undeniably proved that it is quite possible, with the help of rockets, to throw light for a longer time uninterruptedly on an object to be aimed at, provided the separate rockets are fired off after each other at proper intervals. On the other hand, by this method the task of the firer—especially in calm weather—is not easy to perform well, because the rocket composition produces a thick smoke, which, in the absence of wind, completely envelopes the object of attack.—*Ibid.*

Italian Railways.—According to the statement of Messrs. C. D. Tivoli, a colossal company is in course of formation for working all the Italian railways. A capital of twenty-four millions sterling will be required. The company will consist of a group of capitalists, chiefly Italian and French bankers, with the Duke of Galliera at their head.—*Ibid.*

Testing of Chrome-Iron.—For testing chrome iron, Herr Ditmar melts half a gramme (7½ grains) of it with 5 grammes (75 grains) of a previously melted glass, consisting of 2 of vitrified borax, and 3 of a mixture of equal equivalents of carbonate of potash and soda, admitting air, till the mineral is completely dissolved. The heat of a Bunsen lamp is sufficient for the purpose. The molten mass is dissolved in water, and the chrome found by filtration, with a solution of protoxide of iron.—*Ibid.*

A New Metal Alloy.—A new metal alloy of beautiful silver white, which is also remarkable for its cheapness, has lately been discovered. It is obtained by mixing together one part of pulverised manganese ore of the best quality, one of pulverised copper refuse, and two of bone-black, and exposing this mixture to a strong red heat in a black-lead melting pot. After cooling, a metal regulus appears at the bottom of the pot, which possesses the most beautiful silver white, can be filed, rolled, and drawn, and on account of its remarkably fine ring is well suited for making bells.—*Ibid.*

Artificial Petroleum.—It is remarkable that hitherto no attempt has been made to produce artificially the carburets of hydrogen, which constitute ordinary petroleum. Only lately, Herr Byasson undertook this task, and, it is said, successfully accomplished it. The attempts he made were founded on the fact that the mineral oils represent nothing else than the coal strata lying at various depths. He conducted a mixture of carbonic acid and steam on to a red-hot iron plate, by which a combination of carburet of hydrogen was formed, possessing all the essential properties of petroleum. In this way he succeeded in producing more than 100 grammes of this artificial petroleum. These experiments are not merely of interest in a scientific, and especially a geological, point of view, but may also lead to practical uses, as in many branches of industry carburet of hydrogen, possessing a definite chemical composition, is sometimes required.—*Ibid.*

Insoluble Indian Ink.—Most of the Indian ink of commerce has the disadvantage of being liable to wash out on the application of a pencil filled with water. Adding alum is of little use. On the contrary, bi-chromate of potash is an excellent means of rendering the glue in Indian ink proof against the action of water, and thus making the ink indelible. It is sufficient to mix thoroughly 1 per cent. of it, in a very finely powdered state, with the dried Indian ink which contains glue. Both substances must be in a dry state, otherwise the mixing will not answer. The artist who cannot provide himself with such ink should, when rubbing in his Indian ink, make use of a weak solution of bi-chromate of potash, instead of the customary alum water.—*Ibid.*

Gold-Parting.—In the Frankfort gold and silver parting establishment the silver contained in sulphuric acid solution is precipitated by means of iron instead of copper. The objections to this practice are, the loss through the development of hydrogen, the precipitation of copper at the same time, and the rendering of the silver impure by phosphorus, silicum, &c. These evils are avoided by crystallising the sulphuric acid solution of silver with the addition of some water, and reducing the crystals of sulphate of silver with iron scrap, stirring the crystals with water, and adding iron gradually, so that every trace of the silver is precipitated, while copper remains in solution. The impurities in the iron go on the melting of the silver into the dross, so that the silver becomes purer than formerly with the use of copper. The chief advantages of this method are—saving in acid, since the mother lye from the crystals again go into the solution vessel; avoidance of the purchase of copper, which is turned to poor account as vitriol; and saving of steam, since the solution becomes very hot of itself.—*Ibid.*

Contribution to the Theory of Lumimous Flames.—Dr. Karl Heumann.—In this part of his treatise the author arrives at important results, both theoretical and practical. He shows that the carbon in the flame exists as a solid body and not, as Frankland assumes, in the state of vapour. He finds that gas-jets of steatite are decidedly preferable to those of iron, since they consume less gas for an equal strength of light. Metallic jets, in general, notably enfeeble the light. He refers to the results obtained by the Commission of the English Board of Trade, who reported, in opposition to the view of Vogel, that a refrigeration of the gas does not decrease the amount of light, and considers that they must have experimented with a kind of gas poor in hydrocarbons capable of condensation. On the contrary, he finds that if the jet and the outflowing current of gas are both strongly heated, the luminous effect is increased to an extraordinary degree.—*American Chem. News, xxxiv. 206.*

The Use of Lead in Lining Receptacles of Drinking Water.—*The Bulletin de la Société Industrielle de Rouen* gives the followng conclusions at the close of a long article on this subject:—

1. Lead ought not to enter into the composition of the lining of vessels containing water that is to be used for food.
2. Even when the water contains only traces of this metal, it is always injurious.
3. Alloys of 25 to 50 per cent. are very dangerous, for they are very easily attacked, especially by sea-water. Lining should be made of pure tin, especially for sea service, as it is often impossible during a voyage to pay proper attention when illness occurs.
4. The sickness on board the Caldera, in its voyage from Havre to Buenos Ayres in 1874, was owing to the faulty composition of the lining of the copper distilling apparatus and cooking utensils.

The use of lead for these purposes has since been forbidden by several decrees of the Tribunal of Rouen.

Violet Light for Photography.—M. D. Scotellari recommends violet light for photographers' studios. It operates, he says, more rapidly than white or blue light, and thus diminishes the length of the sitting by nearly a half. In consequence of the homogeneous character of the tint thrown upon the face, the impressions are more satisfactory, and require little re-touching. As to the fidelity of the portraits, some persons being very impressionable in ordinary light, and not so under the exclusive influence of violet rays, the likeness obtained is perfect, and the face calmer. As to artistic effect, photographs taken in *exclusively* violet rays are better modelled, in better relief in the light parts, and more deeply marked in the shady parts, so that the portraits stand out with remarkable clearness and finish.—*Comptes Rendus, tom. lxxxiii., No. 19.*

Mucilage for Labels.—Those who are engaged in gumming labels are often annoyed by the curling up of the edges or corners. A remedy for this is to add to the mucilage a little salt, sugar, and glycerine, and the paper, if not exposed to too strong a warmth, will not curl. A very small quantity of glycerine must be used, as a large proportion will prolong the process of drying.—*New Remedies, v. 352.*

The Properties of Gallium.—The recently discovered metal, gallium, melts at 81·1 degrees Fahr., so that it liquefies when held in the hand. When solid, the metal is hard and resistant, even to a few degrees below the melting point. It can be cut, and possesses a slight malleability. When fused, it adheres

easily to glass, on which it forms a beautiful mirror, whiter than that produced by mercury. It oxidizes, but very superficially, when heated to redness in the air, and does not become volatile. The density at 59 degrees Fahr. is 4·7. Excepting mercury, which only becomes solid at —40 degrees Fahr., there is no other element which liquefies at so low a temperature as gallium.—*New Remedies, v. 333.*

Antidote to Strychnia.—The East Indian physicians recommend nicotia as the surest antidote, which is given in exceedingly small quantities in sherry several times a day. In default of nicotia, decoction of tobacco leaves (half an ounce to a pint) is given.—*American Journal of Pharmacy.*

Ink Stains may be removed from coloured fabrics which would not bear the application of acids, chloride of lime, or other strong agents, by a concentrated solution of sodium pyrophosphate (*R. Bættger*). Old stains do not yield at once, but require a prolonged application.—*New Remedies, v. 352.*

Explosion of Fire Damp.—M. J. J. Coquillion reports to the Academy of Sciences that he has repeated Davy's experiments on fire-damp explosion in different circumstances, with a view to ascertain precisely within what limits it can take place. He found it difficult to obtain a loud report with small quantities of gas as in laboratories. The general result of his experiments was, that explosions may occur within far wider limits than is generally supposed. Thus, for one part of fire-damp, the quantity of air may vary from 6 to 16, although at these limits the danger is no longer serious. He also found that pallodium may be safely raised to red heat in one of the most detonating mixtures that are known, the only result being a diminution in the volume of the gaseous mixture.—*Abridged from Comptes Rendus, tome lxiii., No. 15.*

Use of Vanadium in the Manufacture of Aniline Black.—It has been found by M. G. Witz, who has experimented on the action of vanadium upon mixed solutions of chlorates and hydrochlorate of aniline, that oxidation is considerably hastened in proportion as desiccation concentrates the baths; while, on the contrary, they become slower as the liquids are more diluted. Having observed that the reaction begins not suddenly, but almost imperceptibly at first, afterwards becoming more rapid, and being completed in a length of time directly proportional to the quantity of metal present, though always very small, he applied the mode of forming aniline black to colours thickened for printing.

By several successive experiments on the addition of metal in decreasing geometrical proportion, he ascertained the infinitesimal proportion of vanadium that it suffices to use in the colour in order to produce oxidation of the aniline, and came to the conclusion that in printing only hundred-thousandth parts of the weight of the aniline salt should be used, and that it is impossible to go far beyond that limit without decomposing the thickened colour itself.

He has for several months printed considerable quantities of pieces in aniline black, modifying within certain limits the additions of vanadium, which always give a rapidity of oxidation proportioned to the quantity of metal employed. This last is an important practical result.

Preparations of sulphuret of copper have been completely abandoned and replaced by vanadium, which ensures most speedy and perfect results, avoids the coppering of the steel plates and the attack of the metal of the engraved rollers, and, what is remarkable, the thickened colours may be preserved for several weeks without any change for the worse. In addition to these advantages, vanadium now costs scarcely an eleventh part of what has always been given for sulphate of copper. All soluble compounds of vanadium will answer the purpose, since the contact of chloric acid always brings them to the maximum of oxidation.

The quantities of vanadium to be added to analine black colours generally vary in inverse proportion to the concentration—*i.e.*, the proportion of aniline they contain—as well as the greater or less heat and length of time devoted to the oxidation of the impressions. M. Witz states the advantages of printing on cotton with vanadium added to aniline black to be the following:—

1. Increased richness of the black and distinctness of the impression.
2. Prevention of the attack of the doctors and rollers.
3. Facility of regulating the duration of the oxidation at will.
4. Long preservation of the thickened colour.
5. A simple and cheaper preparation than those hitherto employed.—*Comptes Rendus, tome lxiii. No. 5.*

Poisonous Red Wafers.—To ascertain whether red wafers are poisonous, Herr Feldmann recommended the following process at a recent scientific meeting:—Soak a wafer in petroleum, stick it on a pin, and at the moment when it becomes a burning mass, blow gently upon it. During the blowing, the metallic ingredient drops, and should be collected in a porcelain saucer, or a piece of white paper. Even with the naked eye the grains of lead can be perceived, especially if pressed by a hard smooth object, such as the blade of a knife.—*Stummer's Ingenieur, Vol. VI., No. 20.*

Velocity of Storms.—Prof. Loamis found, from the observation of 485 storms, that the velocity of North American storms reaches an average of 26 miles an hour. On the other hand, the average velocity of storms passing over the Atlantic has been found by 134 observations to be 19·3 miles an hour. According to Prof. Mon, Austrian storms reach an average of 26·7 miles an hour. Hence it appears that storms pass with greater rapidity over the sea than over continents. This may contribute towards the solution of the question according to what laws storms move on the earth's surface, in many cases hastened and in others retarded, as may be often observed on the coast of Newfoundland and the Bay of Biscay.—*Stummer's Ingenieur, Vol. VI., No. 20.*

Pneumatic Malting.—A new process of malting, which seems likely to answer well, has lately been introduced at M. Gulland's brewery near Nancy. Its object is to produce malt of perfectly uniform quality all the year round.

The peculiarity of this so-called pneumatic malting is, that damp air of always equal temperature is made to pass over the outspread barley with such rapidity that it removes the superfluous carbonic acid. Hence malt can be heaped to a height of 30 to 50 centimetres (11½ to 19½ inches) on the malt floor, thus effecting a considerable saving of room in comparison with the ordinary process, which does not admit of heaping above 10 to 20 centimetres (4 to 8 inches).

The malt-house consists of closed vaulted chambers of brick work with cement. Supposing the malting to last for ten days at a temperature of 54° F., the malt-house is divided into twelve chambers, so that one chamber may be always kept free. The chambers lie symmetrically on both sides of the middle line of the building, but do not adjoin along this line, being separated by a central air-pipe; another air-pipe goes along the opposite sides of the chamber. The floor of the chambers consists of perforated lead resting on iron supports. The chambers are also in connection with the central air-pipe, which brings in fresh air, and with the pipe at the back, which carries off the used air. Traps or partitions at the junction openings admit of letting the air circulate through the malt layers, either from above, downwards, or in the opposite direction. The used air is carried away out of the pipe at the back of the chamber by a ventilator to the chimney of the whole building.

The newly admitted air is cooled, saturated with moisture, and freed from the accompanying carbonic acid in chambers filled with coke or other materials presenting a large surface: there are two such chambers, one at each end of the malt chambers. On the surface of the cake in each chamber a turniquet distributes cold water, which is either obtained direct from springs—if they supply it at a temperature of only 50° to 54° F.—or cooled with ice. Air comes from below into the coke chambers. Before its admission it meets with two water sprinklers, by which it is very soon saturated with moisture. Should the saturation be not yet complete here, it is made so on the rising of the air into the coke chambers. The air being sucked in through the ventilator, at last goes to the central air-pipe, and out of this into the several malt-chambers. Nineteen-twentieths of the used air is always used again, and only one-twentieth of fresh is added.

As advantages of this method, M. Gulland mentions that the malt-house can be made about four-fifths less than hitherto, manual labour is lessened by half, malting can be carried on all the year round with perfect regularity, and the malt, on account of the smaller surface on which it is laid, is far less injured by shovelling. The expenses are said to be only half those of previous processes.—*Deutsche Industrie Zeitung, Nov. 30, 1876.*

Grease for Small Machines.—Small machines, such as sewing and knitting machines, graver-spindles, and all mechanical apparatus which rotate swiftly, require for the axle-ends or pivots a grease which does not harden. Common oil does not answer, but ordinary glycerine, chemically pure (but not mixed with water) is recommended, especially for sewing machines, because it makes no grease spot. Hence the cleaning cloths can be easily washed, and there is no danger of spoiling

valuable material or the seam during the work.—*Blätter für Industrie und Gewerbe.*

Railway Brakes.—The almost instantaneous stoppage of trains in case of need has always been an object of attention to railway companies. The French Compagnie du Nord have tried two systems of continuous brakes with two trains of twelve carriages each, on the Chantilly line. Each carriage has a brake, and the brake apparatus of the twelve carriages, which are locked together by a coupling, is brought into action simultaneously by a single mechanism and a single movement very easy to perform. Large brakes are no longer needed.

The results obtained by such powerful means and an instantaneous application, far surpass the effects of ordinary isolated brakes, and even some mechanically combined brakes, which till now could not effectually act upon groups of more than two or three carriages.

One of the systems tried was Acherd's electric brake, the other a continuous pneumatic brake, constructed by Smith's Vacuum Brake Company. The initial movement motor, which is the origin of the application of the brakes, is very simple. With the electric brake, the guard acts on the lever of a commutator, and a button is fastened. With the pneumatic brake, you have only to open a steam tap. The unfastening is accomplished in both cases by a contrary movement requiring little force. There is certain safety in the use of continuous brakes, the entire working of which is in the hands of the guard. A train moving with a speed of fifty miles an hour can be stopped without severe shock in less than 360 yards. A still further advance has been made in the same direction. A new combination of the motor apparatus, which has been invented by Messrs. Dedebecque & Banderal, engineers of the Italian Northern Railway, entirely does away with the intervention of the guard. The disc itself, indicating stoppage, acts on the locomotive, the electric commutator, or the tap valve which is the origin of the application of the brakes, and the disc locks without the intervention of any agents on the locomotive and in the sentry boxes, and does this without their knowledge as it were, which is carrying automatic movements as far as they can well go.—*Monitaire Industriale Italiano, Dec. 3, 1876.*

Use of Potatoes in Manufacture.—It seems the potato may be used for manufacturing purposes, as a substance resembling buck-horn, suitable for knife-handles, can be obtained from it. Turnips are also capable of being used for the production of artificial horn.—*Ibid.*

Voyages of Observation round the World.—There has lately been a good deal of discussion about founding a company for making voyages of observation round the world. The company has decided that, after the requisite number of members is obtained, the first of these voyages shall take place this year, so as to be completed by the opening of the Paris exhibition next year. The steamer Hooghly intended for this first voyage, is a vessel 367 feet long and 39 feet broad. It went about 54,000 miles in the Indian Ocean and the Chinese Sea in 1875, with an average speed of 11 knots an hour. It sometimes reached 13 and even 14 knots with the monsoon.

It contains sixty large and well ventilated cabins, most of which are fitted up for four first-class passengers or more. It behaves very well at sea.—*Technologiste, Dec. 9, 1876.*

Italian Iron-clads and Guns.—The Italian Government has given orders for two iron-clads, the Duilio and the Dandolo, the former of which is already afloat, and the latter is to be launched in July. They are to be armed with solid plates, 22 inches thick, and to carry each four 100-ton guns, capable of being fired off all at the same time. They are also to have spurs weighing 17 tons each, and tubes from the prow for discharging Whitehead's torpedoes; Harvey's torpedoes, ignited by electricity, will be also in tow. By means of a steam-ram, a steam-launch in a water-tight compartment can be projected into the sea, to strike the enemy with a torpedo. The engines are of 7,500 horse power, producing a speed of 16 knots an hour.

At a recent trial of one of the guns against a target of soft steel in solid slabs, altogether 22 inches thick, with 29 inches of oak backing, and an iron lining of an inch and a half, the bolt embedded itself in the plate up to the base, and cracked deep rends all over the surface. The powder was of 1½ inch cubes, and the charge 350 lbs., the weight of the projectile being 2000 lbs. A charge of 370 lbs. of English pebble powder threw the bolt more than nine miles, with an initial velocity of 1542 feet. By an enlargement of the bore from 17 to 17½ inches, and of the powder chamber from 18 to 18½ inches, it is expected the powder charge can be increased to 440 lbs., the weight of the projectile remaining the same. This charge will increase the energy to 35,000 foot-tons. The guns will be loaded by hydraulic machinery from the lower deck, four men sufficing for the purpose, and four more for turning the gun in any direction.

To Prevent Iron from Rusting.—A new method of preventing iron from rusting consists in exposing the objects in a heated state to the action of over-heated steam. The iron then gets a thin coating of black protoxide of iron, which protects it from all atmospheric influences. If the objects are already rusty, they are treated with hydrogen gas before being exposed to the action of the steam.—*Arbeitsgeber.*

Cement.—A suitable cement for uniting metals with non-metallic substances may be obtained by dissolving 2¾ lbs. of glue, and 2⅛ oz. of gum-ammoniac in boiling water, and adding about 2⅛ oz. of sulphuric acid.—*Phœnix.*

An Alloy for Small Cast Articles.—An alloy, much recommended for making small cast articles, is obtained by melting together 79 per cent. of cast iron, 19·5 per cent. of tin, and 1·5 per cent. of lead.—*Metallarbeiter, Dec. 7, 1876.*

Use of Phosphoric Acid in the Clarification of Sugar.—In a note published by M. Vibrans in the Journal of the Association of Sugar Industry in Germany, the use of phosphoric acid in the clarification boiler is strongly recommended, having been found by experiment to answer well. All the acid used may be recovered, and the syrup reaches the filter in the best state. There is also a saving of bone-black and hydrochloric acid, and the syrup, thus treated, evaporates better, and gives a mass of filling material which is distinguished by a feeble proportion of substances that are not sugar.—*Technologiste, Nov. 25, 1876.*

Railway-Carriage Propeller.—The labour and difficulty of moving carriages in railway stations is well known. To move a single loaded waggon often requires six or eight men. Herr Heshuysen, an engineer at Amsterdam, has invented a simple and practical apparatus for lightening this labour. It consists mainly of a two-armed lever, one arm of which is hung on to the wheel-axle of the carriage to be moved. The end of this arm is bent into a semi-circular form to lie on the circular arm of the axis. The end of the other arm is connected link-wise with that of the first-named arm, and this link forms the fulcrum and turning-point of motion, which lies between the axis and the circumference of the wheel. On the second arm there is an adjunct which fastens on the flange of the wheel. When the lever moves up and down, this and the wheel turn about different centres, and the carriage moves forward.

When the apparatus is to be used to push a waggon, it is hung on to the axis of the waggon firmly at the inner side of the wheel with its iron hook, in such a manner that both arms of the lever are parallel to each other. The length of the arm is then so adjusted by a screw that the side gudgeon on the lever fastens on the flange of the wheel. The lever has now only to be moved up and down, and the waggon moves forward.

The saving of labour is so great, that with this apparatus one man is able to do the work of six men. The Belgian Government has acquired the right of manufacturing it, paying the inventor a royalty. The apparatus, which is adapted for moving carriages at all stations, is especially to be recommended for those that have branch lines. It is patented.—*Deutsche Polytechnische Zeitung, Nov. 18, 1876.*

New Injectors for Boilers.—In steam-engines, especially locomotives, the exhausted steam is used to produce a strong draught in the furnace. This steam comes from the cylinders; and, being first collected in a tube with narrow mouth, is discharged into the chimney of the engine.

This forced method of exciting the fire is Robert Stephenson's valuable invention, without which the locomotive would not exist. But it is obvious that the operation renders it necessary to abandon the condensation of the steam, even when there is no occasion to use the whole of it for producing the draught in the furnace, which involves—

1. A considerable loss of heat with the steam used for the purpose of the draught.
2. A consumption of water, leading to a greater dead weight to be carried.
3. Shorter duration of the boiler, which can no longer be partly fed with distilled water, through the condensation of the steam.

It is not surprising, therefore, that for a long time engine-manufacturers have sought to avoid these disadvantages. Till the beginning of last year the best apparatus known and employed on some railways were those of Clarke and Hirchwoger. But the complication of the former, and the imperfection of the latter, have prevented their extensive use.

Signor Chiazzari as far back as 1864 commenced studies and experiments with a view to discover some improvement, and has at length contrived the following apparatus:—A pump, set in motion by one of the cylinders, the piston of which has two faces of different areas, alternately draws the water from the tender into one of its two chambers corresponding to the smaller face, and forces it into the opposite chamber, which presents a larger capacity, where the water mixes with a suitable quantity of exhausted steam, taken a little below its entrance into the chimney. Care is observed in the internal arrangement of the apparatus, so as to obtain perfect condensation of the steam on its meeting with the water, the temperature of the mixed liquid reaching usually 203° Fah. The mixture is afterwards thrown by the pump into the boiler.

The apparatus is furnished with an addition which may be called the regulator. It consists of a double syphon, and is worked by opening or shutting more or less, on the point of departure, two keys placed within reach of the engine-driver. It has two important functions: First, to prevent the penetration of the water of the tender into the motor cylinders when the locomotive is at rest; and, secondly, to render uniform the heating of the water inside the body of the pump, in spite of the intermittent character of the jet of steam supplied by the cylinders.—*Rovista Scientific Industriale.*

Length of Railway in all Countries.—In the following years the lengths of railway open throughout the world were, in kilometres (the kilometre = ·621 mile):

1850,	38,022
1855,	68,148
1860,	106,886
1865,	145,114
1870,	211,859
1875,	294,249

The increase in length of railway in the great geographical divisions, from 1860 to 1875, is shown by the following table:—

	1860.	1865.	1870.	1875.
Europe,	51,544	75,149	103,744	142,944
Asia,	1,397	5,568	8,132	12,302
Africa,	446	837	1,773	2,372
America,	52,235	62,735	96,398	133,552
Australia,	264	825	1,812	3,079
Total,	105,886	145,114	211,859	294,249

The following are the lengths of railway open in the countries composing the geographical divisions of the world:—

EUROPE.

	Kilometres.
Belgium,	3,517
Great Britain,	26,870
Switzerland,	2,066
Germany,	27,980
Holland,	1,895
France,	21,587
Denmark,	1,260
Austro-Hungary,	17,368
Sweden,	4,138
Italy,	7,704
Spain,	5,796
Roumania,	1,233
Portugal,	1,033
Russia,	18,488
Turkey,	1,537
Norway,	555
Greece,	12

ASIA.

Caucasus,	1,004
India,	10,443
Ceylon,	132
Java,	261
Asia Minor,	401
Japan,	61

AFRICA.

Mauritius,	106
Algeria,	537
Cape Colony,	201
Egypt,	1,528
Tunis,	60

AMERICA.

United States,	119,352
Canada,	6,719
Cuba,	640
Chili,	991
Uruguay,	305
Peru,	1,549
Argentine Republic,	1,584
Panama,	76
Jamaica,	47
Honduras,	90
British Guiana,	96
Paraguay,	72
Bolivia,	30
Brazil,	1,338
Mexico,	607
Venezuela,	13

AUSTRALIA.

Victoria,	1,004
New Zealand,	402
New South Wales,	702
South Australia,	408
Queensland,	423
Tasmania,	72
West Australia,	64
Tahiti,	4

The above figures represent the lengths of railway open up to December 31, 1875, for Europe, the United States, and Canada. For other countries they refer to the beginning or middle of that year.—*Economista, December 10, 1876.*

Brassing of Wrought Iron.—As in many cases electro-brassing is not sufficient, the following process, which has been found useful, is worth attention. The objects are dipped with 5 per cent. sulphuric acid, and then passed through 1 part by weight of chloride of zinc, 2° Baume, and 5 of water. They are afterwards dipped for a long time in a fusing mixture (which is covered with borax), composed of 92 parts by weight of copper, 2 of tin, and 1 of zinc. They are thus covered with an adherent copper coating, after which they are dipped into the brass bath, consisting of a fusing alloy of 2 parts of copper and 1 of zinc.—*Metallarbeiter, December 7, 1876.*

Warning against the Use of Toughened Glass Cylinders in Safety Lamps.—For some time cylinders made of toughened or tempered glass have been recommended. They are remarkable for strength; but this toughened glass possesses properties which may be dangerous, particularly that of breaking up into small pieces when it breaks at all, and not simply cracking as ordinary cooled glass does. This is the peculiarity of the so-called Venetian glass drops also, which are produced by throwing rather long hollow glass drops while glowing hot into warm water, and there tempering them. If the end is broken off, the drops break to pieces with an explosion, as the artificial state of tension in which the molecules are placed is suddenly terminated.

Toughened glass acts in precisely the same way, being produced in a similar manner. The objects to be tempered are dipped while glowing red with heat into a hot bath of oil, melted fat, or a mixture of these with glycerine, and suddenly cooled to the temperature of the bath. The great difficulty is to maintain suitable temperatures in the furnace and the bath, according to the thickness of the glass. Well tempered glass may be thrown against wood without easily breaking; but if it be spoilt or injured in the tempering, it immediately falls to small pieces. It has even repeatedly happened that lamp cylinders, long after the gas has been put out, have exploded and broken up.

This property of toughened glass evidently renders it quite unfit for safety lamps, since the protection they should afford may at any moment prove illusory by the breaking to pieces of the protecting cylinder. Hence its use ought to be forbidden in mines. Well cooled thick glass cylinders will alone afford the requisite security, as they do not cause any danger, even if they crack.—*Gurlt in Polytechnische Zeitung.*

New Writing Ink.—According to a receipt of Roque Moschini, a superior ink for writing may be thus prepared:—

Lactate of iron,	1 gramme (15·4 grains).
Pulverised gum arabic,	5 „
Pulverised lump sugar,	2 „
Gallic acid,	6 „
Hot water,	100 „

The whole should be dissolved and cleared of solid particles.

In this way a fluid, non-decomposing black ink will be obtained, which, instead of attacking steel pens, adheres to them.—*Stummer's Ingenieur.*

Restoration of Damp Corn.—Damp corn, which has become mouldy, may be restored by mixing it with coal dust. The coal should be separated from it three weeks afterwards by a winnowing machine. To dry damp corn, unslaked lime should be placed near it in baskets. To 500 kilogrammes (1,100 lbs.) of corn, about ·04 cubic metre (one-twentieth of a cubic yard) of burnt lime should be used. The crumbled lime may still be used for manure and other purposes.—*Ibid.*

Preservation of Blood in Slaughter Houses.—Fresh blood in slaughter-houses may be preserved intact by the addition of slaked or unslaked lime in powder or small pieces. The lime is precipitated in the blood, and a gelatinous mass is formed, which is dried in the sun or by artificial means, if it is to be kept for any length of time. If it is to be used at once, it should be mixed with flour or any nutritious substance in the form of dry powder.—*Ibid.*

A New Method of Washing.—In some French towns a new method of washing has lately been introduced, which deserves mention. A kilogramme (2·2 lbs.) of soap is made into a sort of paste by mixing it with a small quantity of water. It is then warmed, and afterwards cooled in 45 litres (10 gallons) of water, to which are added a table-spoonful of oil of turpentine, and two of ammoniac. The mixture is well stirred, and the water must be kept at a temperature of about 86° F.

In this solution the articles to be washed are soaked, and left there for two hours, before they are washed with soap. The soap-water can be warmed again, but some turpentine and ammoniac must be again added. After the clothes have been washed with soap, they are put into warm water, and immediately coloured with blue.

This process, which involves a considerable saving of time, is also very economical, as the cost of washing is reduced about 100 per cent. Moreover, the use of brushes and other means which wear out the clothes, is quite needless, and the dirt is removed by the solution alone.—*Ibid.*

New Wood Pavement.—One of the principal streets in Paris will shortly be paved by way of trial with a wood pavement which, instead of being laid on planks impregnated with creosote, the joints being filled up with sand and pitch, as hitherto in this country, is to be laid on sand, the joints being filled up with hydraulic cement.—*Ibid.*

Hardening of Zinc.—By adding 100-200 grammes (3½ to 7 lbs.) of sal-ammoniac to a fluid zinc bath, a product may be obtained which possesses much greater hardness than ordinary zinc.—*Ibid.*

New Tin Boxes.—Mr- Henry Martin, of Boston, in America, has lately introduced an improvement in tin manufacture, which consists in making tin boxes of all sizes out of a single block of tin, by means of a series of differently formed punches. During the pressing out, the corners and edges of the boxes are doubled together, by which a perfectly air-tight closing is obtained without the use of any solder. The tin boxes are very durable and very cheap, being produced at the rate of several dozens a minute.—*Ibid.*

Aurantia, a New Orange Colouring Substance.—The Berlin Society for the manufacture of aniline colours, has for some time prepared for commerce, under the name of *aurantia*, a new substance which dyes wool and silk with a very fine orange colour. According to a communication of Herr R. Gnehm to the German Chemical Society, it would appear that this substance is the ammoniacal salt of hexanitrodiphenilamine. From the statement of this chemist, it would seem to possess poisonous properties, and to attack the skin especially with violence; but M. Martius protests against this assertion, and thinks these deleterious properties are attributable to impurities.—*Technologiste.*

Furnace for Burning Ceramic Products, Lime, &c.—Siemens's regenerator system of heat has been applied with success in metallurgic and other industries, but its construction involves considerable cost, and leads to expense when it gets out of order, as sometimes happens. Moreover, it requires pretty large development to work conveniently.

Herr C. Nelse, an engineer at Dresden, has invented an arrangement based on the same principle, but much less expensive, which he has already applied with success to the manufacture of glass and mirrors, ceramic products, the burning of lime, bricks, &c.

The starting point in the construction of kilns and furnaces according to this system, is the same as that of the Siemens regenerators; that is to say, the products of combustion which escape, have to serve for heating the atmospheric air which supports combustion, but in a simpler, more certain, and more profitable way. For this purpose, Herr Nehse makes these products pass, while going from the furnace to the chimney, into a series of fire-proof brick flues, surrounded by other flues, through which the atmospheric air circulates in a contrary current, and is heated on the way, at the same time that it robs the products of their excess of heat, which it utilises in the furnace. In this construction, experience has shown that the gases, before entering the chimney, are cooled to 390° or 570° F., while the air which feeds combustion is heated from 1470° to 1830° F.

By the aid of this simple arrangement a very constant current of flames may be kept up in a reverberatory furnace. Some very simple arrangements serve to regulate the intensity of the fire, consisting of registers in the flues of the products and those of the air, so as to obtain at discretion an oxidation or a reduction fire.—*Ibid.*

Process for Extracting Moth from Cloth Fabrics.—Mr. A. J. Cook, of Michigan, in a pamphlet on noxious insects, gives the following directions for the extraction of moth from woollen materials, carpets, &c. Take a piece of wet linen or other material moistened with water; spread it out on the moth-infested material, and iron it all over with a hot iron. While the moisture in the wet cloth is converted to steam, it penetrates the material underneath, and destroys the whole brood of moth insects.—*Gewerbeblatt aus Württemberg.*

A Substitute for School Black Boards.—Prof. Marx, of Stuttgart, says, that, having frequent occasion to use the black board, he often regretted the necessity of rubbing out what he had written or drawn upon it, as soon as the lesson was over, knowing that in a short time afterwards he would have to repeat it. To remedy this inconvenience, he procures from a paper hanging manufacturer dull black paper, about a yard wide, from which he cuts off as much as he wants from time to time. He fastens the paper with pins to the board or a smooth wall, and writes or draws on the paper with ordinary chalk, as on the black board.

He fixes the chalk on the paper by means of a sprinkling apparatus—such as can be obtained from dealers in glass or india-rubber—moistened with a diluted solution of shell-lac in spirits of wine. On the moistening, the chalk apparently vanishes, but re-appears on drying. The solution consists of 50 grammes (an ounce and three quarters) of bleached shell-lac in a litre (a pint and three quarters) of ordinary alcohol at 180° to 195° F. Before use the solution should be drawn off clear or filtered, and kept well corked.

The strength of the solution is a point of importance. If it is too great, the moistened parts glisten after drying, and the drawing or writing looks bad. On the other hand, if it is insufficient, it does not produce the desired effect. The alcohol should at least be so strong that the solution dries as quickly as possible, and does not run. If the apparatus is in good order, several square yards of paper can be moistened in a quarter of an hour, and rolled up without rubbing out the chalk. —*Ibid.*

Directions for the Use of Salicylic Acid in Housekeeping.—Dr. von Heyden gives the following directions with regard to the use of salicylic acids in households:—

1. With raw meat. It often happens that in warm weather the parts of meat most liable to decomposition—snch as the fat and blood—are found to be tainted. This may be remedied either by laying the meat before being cooked in tepid water, to which is added from half to a whole tea spoonful of dry salicylic acid to a pint and three quarters of water, or by sprinkling a few pinches of salicylic acid in the water during boiling. To keep meat good for several days, either—

1. Lay it in a solution of salicylic acid, consisting of a pint and three-quarters of water, and half to a whole tea spoonful of salicylic acid; or—

2. Rub the meat in lightly with dry salicylic acid, especially at the bones or fat parts. It must be previously cleaned as usual. Though raw meat loses its colour on the surface, when treated with salicylic acid, it is not at all affected internally. It also boils tender in a shorter time. For sprinkled meat the addition to the ordinary pickle of 23 grains to a pint and three-quarters is a great improvement.

II. Pure milk, to a pint and three-quarters of which is added half to a whole tea spoonful (about 7½ to 15½ grains) of crystallised salicylic acid (not in aqueous solution) keeps from curdling about 36 hours longer, and makes excellent cream and butter.

III. Butter kneaded with salicylic acid (a tea spoonful to a pint and three-quarters of water), or kept in it, *e.g.*, pushed in cloths saturated with aqueous solution of it, keeps good longer, and butter already rancid may be improved by careful washing with aqueous solution (31 to 46 grains to a pint and three-quarters of water), and afterwards rinsing with pure water.

IV. Preserved fruits (cherries, currants, apricots, &c.) should be thus prepared—Put the fruit into a not very wide-necked bottle or jar in alternate layers with sugar, without water, sprinkle over it about 8 grains of salicylic acid to 2 lbs., tie the vessel up with parchment soaked in an aqueous solution of salicylic acid, and steam it as usual. Bilberries are best boiled without sugar, left to cool, put in narrow-necked bottles with some crystallised salicylic acid, sprinkled on them, corked, and sealed. Fruits preserved in this way have kept well for two seasons. On the top of the preserve a piece of blotting paper should be laid, which is saturated with a concentrated solution of salicylic acid in rum.

V. For boiled vegetables, pickles, and other preserves, a small quantity of dry salicylic acid is sufficient to keep them good.

VI. Fumigation with salicylic acid, by evaporating by acid on a hot iron plate, will completely purify and disinfect the air and walls of close rooms.

VII. Vessels, corks, &c., which have a bad smell, may be thoroughly cured by washing them with salicylic acid. A suitable solution may be prepared with two or three spoonfuls of salicylic acid to a pint and three-quarters of water, which should be quickly boiled and left to cool. What remains after the boiling is pure salicylic acid, which can be either reserved for future use, or employed at once where a greater effect is desired than the ordinary solution produces.—*Ibid.*

English Railways.—From a report recently issued by Captain Tyler we gather the following particulars :—

The total length of railway open in the United Kingdom to December 31, 1875, was 16,658 miles; of which, 8,898 miles have two or more lines, and 7,760 single lines. In England there were 11,789 miles of railway, in Scotland 2,721, and in Ireland 2,148.

Compared with December 31, 1874, there is an increase of 209 miles; of which 167 are in England, 21 in Scotland, and 21 in Ireland.

The total capital invested in railways at the end of 1875 was £630,223,494, being an increase upon the previous year of £20,327,000. The average cost per mile, which was £34,099 at the end of 1858, had risen to £35,984 at the end of 1872, to £36,574 at the end of 1873, to £37,088 at the end of 1874, and to £37,833 at the end of 1875. This increase is not owing to an increase in the cost of constructing a mile of railway, which is on the contrary less, but to the necessity of providing new buildings for the increased traffic, and making a greater number of extra lines, large stations and workshops, and ponderous engines.

Up to December 31, 1875, there were lines representing a share capital of 43 millions—or more than 10 per cent. of the whole share capital (amounting to 467 millions)—which had not paid any dividend. Out of 160 millions of borrowed capital, there was only £817,000 which had not paid interest.

The total railway system possessed 12,439 locomotives, or about one locomotive for every mile and a quarter; 393,799 carriages, or 23½ per mile; besides a great number of waggons and trucks belonging to private firms and companies.

The total revenue from railways in 1875 was £58,982,753; of which £32,198,000 was required for expenses, leaving a net revenue of £26,784,753, or 4.54 per cent. on the total capital invested. Hence the expenses are 55 per cent. of the whole gross profit.

The number of passengers conveyed was 506,975,234, besides 397,000 season ticket-holders, and goods, and mineral traffic amounting to 200,069,651 tons.

In 1875 there was an increase in the gross revenue of £2,083,255, of £550,679 in working expenses, and of more than 29 millions in the number of passengers. Between 1858 and 1875 the revenue increased from £23,956,000 to £58,988,000—*i.e.*, was more than doubled in seventeen years.

The ratio of expenses to receipts, which was 49 per cent. in 1870, amounted in 1874 to 54 per cent., in 1875 to 56 per cent., and in 1876 to 55 per cent. The net profit per mile diminishes in England, while it increases in Scotland and Ireland. In 1875 the sum of £591,891 was paid for damages.

A New Adhesive Material.—An adhesive material, which in point of colour and durability far surpasses gum arabic, is thus prepared :—Milk is freed from casein by the addition of acetic acid, and, after being well washed in fresh water, it is dissolved in a cold saturated borax solution. This syrup-like substance, which is perfectly colourless, acquires great brightness on drying, and also possesses very strong adhesive properties.—*Stummer's Ingenieur, December, 1876.*

The Population of the Earth.—According to statistics lately published by Messrs. Behm and Wagner, the total population of the earth amounts to 1,423,917,000 souls. Of this number there are in—

Europe,	309,178,300
Asia,	824,548,500
Africa,	199,921,600
Australia and Polynesia,	4,748,600
America,	85,519,800

The average population throughout the world to the square mile is 28. It is, of course, greatest in Europe, where there are 82 to the square mile. In Asia there are 48, in Africa 18, in America 5½, and in Australia and Polynesia, 1½.

Pantopollite.—This name is applied to a cheaper sort of dynamite lately invented. It contains a per-centage of napthaline dissolved in nitro-glycerine, which is said to prevent the formation of oppressive hyponitric acid vapour. On its being used at the Friedricksthal mine, the explosive action was found to be very good, but the smell and smoke produced afterwards were so disagreeable that for a considerable time no work could be done, and the men suffered severe pain in the head and chest. Only one-third of the usual charge was required to produce the desired effect, and the coal was broken into much smaller pieces than with gunpowder.—*Stummer's Ingenieur, Dec., 1876.*

A Gigantic Clock.—Messrs. Dent & Co. have completed a gigantic clock for the Crystal Palace. The dial is the largest in existence. Its diameter is 40 feet, and its superficial area nearly 1,300 square feet. The diameter of that of the Westminster clock is only 23 feet. The hands, with their balance-weights, weigh nearly 5 cwt., and the minute hand is 19 feet long. It moves so quickly at its extremity, that it describes half an inch at every stroke of the pendulum. In the course of a week the end passes over four miles. In spite of these colossal dimensions the clock goes remarkably well, and in seventeen days varied only 8 seconds.

Coal-Smoke as Lacquer.—It is often necessary to cover sheet-iron with lacquer for the sake of appearance, especially in the manufacture of stoves for rooms, heating apparatus, &c. Yet it is not easy to meet with a good lacquer for fire; and even if the lacquer will stand fire, it produces an unpleasant smell when heated, unless it is properly burnt in and dried. The following process prevents this incovenience, and is cheaper and easier than the usual ones :—

Take smooth, bright sheet-iron (cleansed, if possible), moisten a piece of cloth with boiled linseed oil, and rub the surfaces with it lightly, so as to give them a dull appearance. Then expose them to the action of smoke from a coal-fire well kept up, taking care that the flame does not touch them. In a few minutes the smoke will have coloured the oiled surfaces. The operation can be repeated, if it is not completely effectual at first, without rubbing in oil again. The article should then be put on a board or table, and rubbed lightly with a cloth smeared with yellow wax as a polish. As the sheet-iron gradually cools, the wax should be removed by continual light rubbing with a clean cloth, after which a black gloss will appear, which surpasses lacquer in durability, and on being heated does not smell unpleasant. It also bears greater heat than the best lacquer.—*Metallarbeiter, December 14, 1876.*

Zinc and Iron Alloy.—The well-known pasty mixture that appears at the bottom of vessels in which zinc has been long fused has been found to consist of 90 per cent. of zinc and 10 of iron, or 8 equivalents of the former and 1 of the latter. The alloy well liquated is composed of small crystals hanging loosely together, which easily crumble, and produce a sandy, beautiful dust, shining like nickel. With very strong heat another alloy is formed, and about 75 per cent. of tolerably pure zinc can be poured off from the new sediment.—*Ibid.*

Iron Cement.—A good iron cement may be thus prepared:—Mix together 8 parts of dry saw-dust, 2 of sal-ammoniac, and 1 of sulphur. Immediately before use take the necessary quantity and moisten it with some water, so that the mixture is not pappy, but only wet. In a short time chemical affinity will operate in the mixture, which will become warm and give out the smell of sulphuretted hydrogen. When the heat is so great that the hand cannot stir the mixture, pour in sufficient water to cover it, and it will then be fit for use.—*Ibid.*

Lubricant for Wooden and Iron Combs.—A good lubricant for combs made of wood or iron is thus simply prepared:—Collect the droppings of oil and tallow used for lubricating machinery, and melt them together. Then mix with them some sifted glass-dust, and smear the iron and wooden combs with the mixture. The glass particles penetrate into the pores of the combs, which are thus rendered hard and smooth.—*Ibid.*

White Bronze.—A company has been formed to work Mr. Parson's patent for the manfacture of a new alloy called white bronze, composed of ordinary bronze and manganese, and the tenacity of which is 50 per cent. greater than that of cannon bronze. Trials made with a bar of it showed that the bar was stretched 9 per cent. of its length before breaking. By hammering and rolling its ductility rose to 30 per cent. The inventor states that the metal is susceptible of hardening.—*Revue Industrielle, Dec. 20, 1876.*

Manufacture of White Lead.—The objects of Mr. John Martin's invention for the manufacture of white lead are—1. The making of white lead by the decomposition of a solution of acetate or nitrate of lead by the action of carbonic acid gas in combination with metallic lead and an oxide of lead already formed, the two being mixed or contained in the above solution, either in a fluid state or that of paste. 2. The making of white lead by the decomposition of a saturated solution of acetate or nitrate of lead by the action of carbonic acid gas, called forth in presence of metallic lead, or an oxide of lead already formed, or both mixed or contained in the solution, with which operation can be combined at discretion the evaporation of the wash liquor for the purpose of recovering the solution containing the soluble salts of lead to be used again. 3. The formation of a chloride of lead with the litharge or other suitable oxide in presence of metallic lead. 4. The conversion of chloride of lead to carbonate of lead, or white lead, by the action of carbonic acid gas in presence of metallic lead.—*Moniteur Industriel Belge, Dec. 20, 1876.*

Maudet Biscuit.—M. Maudet has made a preparation which combines in a small compass a fixed quantity of very nutritious substances, capable of being kept any length of time without fear of mouldiness, fermentation, or decomposition. It is composed as follows:—

Wheaten Flour, ...	45 per cent.
Beef, Veal, &c., ...	10 „
Pork Fat, ...	5 „
Salt, ...	5 „
Distilled Water, ...	15 „
Fermented Cheese, ...	15 „
Spices, ...	5 „

It is called Maudet biscuit, and may be used dry or baked as ordinary biscuit, and eaten alone, or with bread, or ordinary biscuit, dry or in a liquid state.—*Ibid.*

Electro-Plating.—It is known that Heeren proposed, instead of making the forms for electro deposits conductive with graphite, to cover them with an alcoholic solution of nitrate of silver, saturated with ammonia, and then expose them to fumes of sulphuretted hydrogen. P. Cazeneuve, in the *Comptes Rendus*, recommends dipping the forms in a solution of nitrate of silver and methylated spirits, and after drying, to expose first to ammoniac fumes, then to fumes of mercury developed at 212° F. The reduction of the silver is completed in a few minutes. M. Cazeneuve states that in this way leaves, flowers, insects, and other organic bodies, can be covered with a coating of copper by electro-plating.

Imitation Nickeling.—As nickeling, in many cases, is a substitute for silvering, it may be itself replaced in a simple way on articles of little value, as nails, bolts, &c., especially if they contain copper. Coarse, rasped, or granulated zinc, is boiled for a considerable time in a mixture of three parts by weight of sal-ammoniac and ten of water, the whole being well stirred all the time with a zinc stick. The deposit thus obtained is as bright as silver, and resists mechanical action, as well as a coating of nickel. The use of this process may be especially recommended for such articles as are to receive a second coating, because zinc easily takes any coating.—*Stummer's Ingenieur, Dec., 1876.*

Harmless Glazing.—Various substitutes have been proposed for the injurious crystal glazing used for earthenware, but none have been found successful. M. Constantin has lately made known a receipt for a glazing which contains no poisonous substances, and yet has all the other properties of crystal glazing. A mixture is made of 100 parts of silicate of soda, 15 of powdered quartz, and 25 of lime. This mixture, which is simply spread over the earthenware vessels, and then fused on to them in a fusing furnace, may easily be made more fluid by the addition of about 10 parts of borax, and coloured green or brown with copper or manganese.—*Ibid.*

Water-tight Cement.—A very good water-tight cement may be obtained by dissolving 5 parts of gelatine in hot water, and adding one part of chromate of lime. This cement must be kept in vessels, well protected from light, because it is immediately made insoluble by the sun's beams. The articles to be cemented are first covered over with the fluid solution, put together, and then exposed to sunlight.—*Ibid.*

Subterranean Photography.—A short time ago an exact photographic impression of the workings in a coal mine at Bentley was taken by means of oxyhydrogen light, commonly called lime light, together with burning magnesium. The impression was taken in order to obtain a representation of certain parts of the mine which are the subject of a law suit. The photographs taken are not only valuable for the intended use, but, when seen through a stereoscope, give an exact view of the places. The process for each photograph took 25 to 30 minutes, during which time the sensitive plate was exposed to the action of the light. The difficulties arising from the long duration of the process, particularly that of preserving the necessary moisture in the high temperature of the mine, were soon overcome. This event is of great importance, as it is now proved that an exact image of the interior of mines after accidents may be obtained, which may be useful in deciding disputes.—*Ibid.*

Circular Magnet for Compasses.—M. Emil Duchemin has substituted for the ordinary compass needle two circular discs of little breadth, connected together by a cross piece made of aluminium or some other metal. The cross piece connects the points of strongest magnetisation, which serve as north and south poles. From these to the neutral points, lying between the two poles with which the two discs are also connected, the magnetism diminishes. The cross piece is widened in the middle, and there forms the cup with which the magnet rests on the point. This compass is said to be much more sensitive than the needle.—*Ibid.*

Renovation of Steel.—When steel tools lose their capability of being tempered, this property may be again given to them—*i.e.*, they may be renovated by heating to a bright red heat, and putting them into a mixture composed of 50 grammes (1¾ oz.) of borax powdered, 25 (⅞ oz.) of sal-ammoniac, 10 (6½ dwts.) of red prussiate, and 100 (3½ oz.) of tallow. After cooling, they can be tempered again as before.—*La Gaceta Industrial, Dec. 10, 1876.*

A New Textile Plant.—Agriculturists at Vancluse and the south coast of Europe generally, have been advised to cultivate the *ramiere*, a textile plant with a thread, offering more tenacity than flax. Its cultivation is very simple, if it be in a light soil free from clay, and is watered once a month. It is manured once a year, after the second crop. In Argelia it is cut four times a year. When it has once well taken root, it lasts almost as long as the olive, and resists extreme cold. Its produce is more profitable than that of the vine or meadow-land. It is worked in this country.—*Ibid.*

Electric Reins for Unmanageable Horses.—Mr. Fainher has invented a very simple contrivance for stopping runaway horses. It consists of a small electro-magnet, placed in any corner inside the driver's box, and a little winch within reach of his hand. Conducting wires sewed into the body of the reins establish a direct communication between the magnet and the horse or horses, whatever their number.

One of the wires terminates in the horse's bit, and the other at the crupper, forming a small metallic circle. The electric shock produced by turning the electro-magnet, passes through

the animal from the head to the tail, instantly rendering the most furious animal harmless, and stopping all motion. As soon as the horse becomes restive, runs away, or rears, the driver has only to give two or three rapid turns to the winch to render it motionless, instantaneously stopping it at full gallop.

It has been found by those who have tried the reins, that the electric shock, far from injuring the horses, do them good. —*Ibid.*

An Easy Method of Cutting Gutta-Percha.—It is known that gutta-percha, when in damp places, is not easy to cut with a knife or scissors. All difficulty may be removed by previously dipping the blade of the knife or the scissors in a solution of caustic potash.—*El Porvenir de la Industria, Dec. 23, 1876.*

A New Process for Manufacturing Cement.—M. Judycki, at a recent meeting of the *Société de l' Industrie Minerale*, described the following new process which he has patented for manufacturing cement. All the beds of a quarry are first worked indiscriminately, the limestone being burnt in ordinary kilns. The burnt stones being then sorted to separate the unburnt from the overburnt, they are carefully sprinkled with water, and made to swell for 8 to 10 hours. The whole is then sifted by a grating which allows only the powdered lime and very small pieces to pass through. The parts left behind are again put into the kiln to get rid of the water and produce decomposition of the hydrates formed during the sprinkling, which is rendered visible during the second burning by the abundant disengagement of vapour of an emerald green colour. The second burning is a delicate operation, on account of the small size of the pieces to be reduced, and it is well to perform it with the following precautions :—

The grate of the kiln should be fitted with fire-proof bricks, and covered with a sufficient quantity of small coal, but free from dust. By the side of the kiln, chimneys, measuring about 10 inches across, composed of larger stones to be reduced, should be erected so that their horizontal distance from axis to axis round the larger circumference of the kiln does not exceed five feet. These chimneys should be filled with coal, free from dust, and raised in proportion to the filling of the kiln. At every foot and a half of height these chimneys should be connected by a line of coal round the circumference of the kiln. When the kiln is completely filled, the fire is to be lighted and left till the burning is completed. The stones thus burnt again are reduced to very fine dust by the usual process for cement.—*Annales Industrielles, Dec. 17, 1876.*

Instantaneous Heating of Water.—At a recent meeting of the *Société d' Encouragement* an apparatus for immediately heating water was exhibited. It consisted of a galvanised iron cylinder about a foot and a half high and eight inches in diameter. Inside there were copper tubes wound in spirals, which are in contact with flame when the apparatus is placed on a furnace or gas stove. Water is poured in above, either by hand, or better, by a tap fitted to a reservoir, so as to allow of easily regulating the quantity of water. The water passes into the tubes and all along them, and is the more quickly heated the smaller the feeding tap is. It goes out of the tubes by a pipe at the bottom. The heating surface is so great, owing to the small diameter of the tubes, that the water acquires the desired heat by simply passing them. The apparatus supplies a pint and three-quarters of boiling water a minute, or four pints and a half at 113 deg. F.—*Les Mondes, Dec. 14, 1876.*

Magnetic Lock for Safety Lamps.—It is well known that explosions of fire-damp often occur through the opening of safety lamps by the workmen, and the consequent contact of the flame with explosive gases. Attempts have therefore been long made to furnish safety lamps with such fastenings as to render the opening impossible for the workmen.

Bidder's patent magnetic lock is a simple and effectual method of accomplishing the desired object. It consists of a self acting tappet, which comes into action as soon as the bottom of the lamp is screwed on. The unscrewing of it, and thus opening the lamp, is rendered impossible by the tappet, which is pressed against by a spring. It can only be accomplished by a powerful and expensive magnet kept under lock and key by the lamp cleaner. With this magnet, held under the bottom of the lamp, the wrought iron tappet is drawn back, and the bottom can then be screwed off. A second magnet is in the hands of the person who has to light the lamps that may have gone out in the mine. This lock has the advantage of being quite inside the lamp, and completely protected from injury. The magnet which opens it is so large that it cannot be carried off without observation. It requires very little time to act.—*Oesterreichische Zeitschrift für Bery-und Huttenwesen.*

Sheep in Australia.—More than 25 million sheep will be shorn this year in New South Wales, yielding more than 125 million pounds of wool, which at a shilling a pound amounts to six million and a quarter sterling. The expense of shearing is about twenty shillings a hundred sheep, or £12,500, and that of exportation about the same. It is expected that by the end of 1880 the number of sheep will have increased to 30 millions.

Petroleum Gas.—According to recent calculations, it has been found that 6,560,000 tons of coal were consumed in the manufacture of gas in 1873. It is stated that the same quantity of gas could be made with 600 tons of petroleum, or about half the quantity exported from America to Europe. It is also said the cost of manufacturing gas from petroleum would be less than that of making it from coal, there would be no danger, and the luminous power of the gas would be superior to that of ordinary gas.—*El Porvenir de la Industria, Dec. 23, 1876.*

The Transatlantic Telegraph.—The transmission of telegrams from London to New York requires three times as long as from New York to London. According to statistical calculation, made by order of the Western Union Telegraph Company, a despatch from New York to London takes four minutes 58 seconds, while one from London requires 12 minutes 48 seconds. The telegraphists of New York allege that this difference arises from the method employed in America, but scientific investigation proves beyond doubt that it is to be attributed to certain laws.

Lawrence's Cooling Apparatus.—The chief advantage of this apparatus over others is, that it can be more easily cleaned, which is very important in practice. In ordinary apparatus the beer flows through very narrow and crooked pipes, with sharp angles and elliptical section, which are surrounded by a pipe filled with water flowing in a contrary direction. The cleaning of such pipes is very difficult. In Lawrence's apparatus the warm beer flows slowly down from above on to the outer surface of a chest made of curved sheet iron, while the cold water inside the chest rises from beneath upwards and there flows out. The surfaces on which the beer falls are everywhere accessible from without, and can be easily cleaned. Similar apparatus may be used for cooling other liquids also.—*Metallarbeiter, Dec. 21, 1876.*

The New York Raised Railway.—This railway is now working. The average of passengers is about 8,000 a-day during the week, and 4,000 on Sundays. Much of the opposition to it has been overcome, and preparations are making for extending the line. The form of iron framework, supported by iron columns, will be adopted for the new lines. The trains will run each way, at intervals of seven minutes, from half-past five in the morning to eight at night.

The company are now working with fourteen goods trucks and twenty-seven passenger cars, which suffice for the daily running of 164 trains, making 82 journeys. The total length of the line is about five miles. The attention of the directors is not confined to the extension of the line. They are also continually making improvements for the convenience of passengers. They are now trying a car with two storeys, which will be generally used if found advantageous. The interior is constructed of hardwood artistically worked, polished, and varnished. The ironwork, heads of bolts, door buttons, and even the rubbing plates for lucifers, are nickelised. The seats are made of beautiful wood and pierced with holes. The body of the car has been reduced in length to allow of the easy lowering of the flight of steps at each platform. In the upper part two benches, placed in the middle, allow the passengers to sit back to back. Light uprights support a canopy at a height sufficient for a person six feet high to stand upright. The wheels are completely hid by a metallic rim reaching to three-quarters of an inch from the ground, so as to clear the rail of little stones that might be in the way and do damage.

Sugar and Oil from Melons.—The melon, which hitherto has served for food only, would seem to be destined to answer more important purposes. It is stated that a method has been discovered of extracting sugar from the pulp and oil from the seeds. It is added that the sugar is superior in quality to that obtained from beetroot.—*Monitore Industriale Italiano, Dec.* 31, 1876.

Measuring the Draught in the Fire-places of Boilers.—To measure the draught in fire-places of boilers use is made of manometers with a double column of water, usually employed to estimate the pressures at various points in a gas-pipe. To render these instruments fit for use in steam-boilers they must be made of two strong crystal tubes, mounted with bronze supports firmly bound together. The height of the tubes may be about 6 centimetres (2¼ inches), their diameter 1 centimetre (nearly ½ inch). They communicate together at the lower end by means of a tube in the lower bronze support. The upper support puts one of the tubes in communication with the external air, and the other with a system of tubes to be applied at the various parts of the fire-place or chimneys that are to be examined.

A double scale, divided into millimetres, is placed between the two tubes. The instrument is applied to the part where observation is to be made—*e.g.*, the door of the fire-place. Then the apparatus is about half filled with water, which is poured into the tube communicating with the outer air. If the door of the ash-pan is open and the draught sufficient, a depression of three or four millimetres ought to be perceived, which may amount to a centimetre when the door of the ash-pan is closed. Less depression would be an indication of insufficient draught. The measuring should be repeated several times from the door of the fire-place to the foot of the chimney. The diminution of pressure between these two extreme points ought to be small, generally not more than three millimetres, unless the chimneys are high and crooked.—*Monitore Industriale Italiano, December 31, 1876.*

Mineral Wax.—The substitution of mineral and vegetable wax for that of bees goes on increasing. A single factory at Frankfort on the Oder annually produces more than 47,000 kilogrammes (929½ cwts.) of *ceresine*. Such is the name given to the product obtained from ozokerite. This last substance is an impure mineral wax composed almost essentially of paraffin, and is principally found in Gallicia, Austria, England, and Texas. The crude substance, freed by fusion from sand, clay, and solid impurities, has a brown colour, with greenish reflections. Its density varies from ·94 to ·97, and its smell is like that of benzine.—*Revue Industrielle, Jan. 13, 1876.*

Velocity of the Propagation of Electricity.—Several distinguished physicists have engaged in experiments to ascertain the velocity with which electricity is generally propagated. But the methods employed were not perfect, and consequently the results obtained did not agree together. Mr. W. Siemens was therefore induced to undertake fresh experiments with newly invented delicate instruments. He arrived at the conclusion that electricity is propagated along an iron wire with a velocity of 240,000 kilometres (149,040 miles) a second.—*Technologiste, Jan. 7, 1877.*

A New Lubricant.—Mr. George Newton has introduced to notice a new lubricant especially applicable to trucks in mines. He takes sifted lime, and adds to it oil, or, still better, spirits of tar. With this compound well amalgamated, he then mixes suitable quantities of resin oil. He thus obtains an excellent lubricant for slow vehicles, such as trucks in mines; but when there is rapid motion, as in railway trains, he adds caustic potash. The lime may be omitted. Mr. Newton has also successfully used a compound of lime, resin, oil, and pitch, previously dissolved in spirits of tar. For certain purposes the lime, oil, and pitch are first boiled.

Electric Autography.—The original idea of the writing telegraph belongs to Abbe Caselli. He first thought of the advantage of transmitting an exact fac-simile of the written message. The process also allowed of reproducing with equal exactness every kind of sketch or drawing. His apparatus did not come into use, because it was cumbersome and costly, and required delicate and difficult management.

At the present time the telegraph authorities in Paris are making trials with two new systems of electric autography, invented by M. Lenoir and M. d'Arlincourt. They are much alike. In both the message is written on a sheet of tin, which is placed on a cylinder. All the strokes made with thick ink are instantly reproduced at the other end of the line by means of a system of very fine hatchings perfectly imitating the message written with printing ink.

The only difference between the two systems is in the mode of reception. M. Lenoir employs a pen, which the current applies to a paper that unrolls, while M. d'Arlincourt makes direct use of the current, which produces an electro-chemical decomposition on prepared paper.

If the systems can be put in practice—as all the experiments hitherto made render probable—important results will follow from this scientific improvement.—*Technologiste, Jan. 7, 1877.*

Nickelisation of Polished Iron and Steel Articles.—The following method of nickelising polished iron and steel articles was described by Herr F. Stolba at a meeting of the Bohemian Scientific Society:—To a diluted solution (5 to 10 per cent.) of the purest possible chloride of zinc so much sulphate of nickel is added as to give it a dark green colour, and it is heated (best in a porcelain vessel) to boiling. Without any regard to the thickening caused by the separation of a basic salt of zinc, the articles (perfectly freed from grease) are put in so as not to touch each other, or only in few places, and kept boiling for half an hour to an hour, the evaporated water being from time to time supplied by distilled water. During this time the nickel is deposited in the form of a bright glistening layer wherever no oxide or fat adheres to the objects. They may be boiled for hours without injury, but without obtaining any much stronger layer of nickel. When they appear nickelised all over, they are washed with water, in which some chalk is suspended, and afterwards carefully dried. The nickel layer bears polishing with chalk very well, and is to be recommended when a firmly adherent but thin layer is sufficient. The appearance of articles so nickelised is very pleasing, especially when they are polished, in which case the layer appears glittering white, with a shade of yellow.

As to the chloride of zinc, it is to be observed that it should not contain any metal liable to be precipitated by iron. Where it cannot be got good, it may be best prepared by dissolving zinc refuse in the purest possible hydrochloric acid, and letting the solution stand with an excess of zinc to supply the loss of the metal precipitated by the zinc. After twenty-fours' action the solution is filtered off and ready for use. It is to be observed that it contains nearly 2·1 parts of chloride of zinc for every part of dissolved zinc.

The sulphate of nickel should also be as pure as possible, and especially should the solution, when brought into contact with polished iron, deposit on cooling no metal capable of being precipitated by it—as *e.g.*, copper. If in consequence of the formation of the nickel-layer, the liquid appears of a pale green colour, fresh salt of nickel should be added until a deep green colour appears. The liquid employed for nickelising, on standing in the air, separates hydroxide of iron, in consequence of the iron taken up, and may be freed from it by filtration, so as to serve repeatedly for nickelising after the addition of some solution of chloride of zinc and sulphate of nickel.

In exactly the same way, by the use of sulphate of cobalt, metallic glistening cobalt may be deposited on polished iron and steel articles. In appearance it is with difficulty distinguished from polished steel only by a slight shade of red, and adheres with extraordinary firmness.

It is also to be observed that iron and steel articles which show annealing colours—as *e.g.*, the blue of steel springs—may be nickelised as above without anything more, as the annealing colour in the boiling quickly disappears, and is soon replaced by a glistening layer of nickel.

Tests of Petroleum.—It has been asked how can bad, dangerously explosive petroleum be distinguished from good. To this question a reply is given in the Riga *Industrie Zeitung*. The usefulness of petroleum may be most simply ascertained by means of the point of inflammation—*i.e.*, the temperature at which petroleum gives out inflammable vapours. This point, according to English and American law, ought not to be below 107° F. The trial is made by heating a small quantity of petroleum in a metal vessel to 107° F., and throwing in a burning match. If the petroleum takes fire, it is bad. In good petroleum, the flame of the match is put out.

Herr Van der Weyde's method of testing is also to be recommended. A glass tube closed at one end (a test-tube) is filled with petroleum, turned up, and put into a vessel of water heated to 107° or 111° F. If the petroleum at this temperature contains gases or vapours that readily explode, they collect in the upper part of the tube, and force a corresponding quantity of petroleum out of it.

The Length of Steel Rails.—The length of steel rails in England, France, Spain, Russia, and Italy, is generally nine or ten yards, and about eleven in America. In Belgium, by way of trial, the South Railway Company has contracted for a thousand tons thirteen yards long. No great knowledge of railway construction is necessary to understand the advantages of a line with rails of great length. Its stability is increased, the shocks caused by joints are much diminished, and there is

a saving in the accessories. Iron rails requiring frequent change must be short to be portable, but this does not apply to steel rails, which last eight or nine times as long as iron ones.—*El Monitor de las Caminos de Hierro.*

Destruction of Smoke and other Deleterious Gases by Combustion.—Various apparatus have been invented for consuming smoke, some of which have been successful more by a sort of luck than through any rational method of construction. The contrivers seem for the most part unaware, that, to obtain the consumption of smoke and gases, it is sufficient to rid the furnace gases of the coaly materials they contain. This excess resulting entirely from incomplete combustion, all apparatus, however varied in form, should ensure complete combustion in the furnace. The simpler the means of doing this the better, provided the gases of the furnace are brought into contact with sufficient air and at a suitable temperature, varying within narrow limits.

Experience has shown that the destruction of smoke takes place, if the following principles are observed :—

1. Having in the grate a thickness of coal not more than four to six inches.

2. Avoiding whatever may lower the temperature of the furnace, and favour the sudden formation of too large a quantity of cold gases.

3. Introducing supplementary air in the zone of combustion.

There is more difficulty in the destruction of offensive gases arising from the treatment of organic matters, as in paper manufactories, potteries, and others. The differences in the combustion of gases prove that there are some which are combustible by themselves, and which may consequently be got rid of by making them pass through a furnace, but that there are others which require different treatment. Consequently, the first thing is to ascertain whether the gases arising from any industrial process are combustible by themselves or not. If they are, a simple passage through a furnace raised to a high temperature will be sufficient, with certain precautions as to the quantity, composition, and intensity of the gases disengaged. If they are not, they form by their hydrogen and carbon a combustible to which a combustive must be given, consisting of oxygen in excess, or atmospheric air.

To accomplish this, the gases must be conveyed to a special chamber, which may be called the combustion chamber, furnished with a furnace and a chimney for the escape of the gases, the dimensions of which must depend on those of the furnace and the quantity of the gases produced. As they are going to the combustion chamber, they should meet draughts of air acting as much as possible in such a way as to interrupt the current of the gases, and completely mix with them. They will thus be charged with the quantity of oxygen necessary to make them burn as soon as they reach the combustion chamber.

To calculate the supply of air required in the combustion zone, it will be necessary to determine—

1. The quantity of gases produced in a given time ;

2. The composition of these gases—*i.e.*, their richness in hydrogen and carbon ;

3. The velocity of the current of gas.

These principles have been applied with decided success at a factory in France.

Abridged from an article by H. Aumont in *La Semaine des Constructeurs, Jan. 6, 1877.*

A Reagent for Determining the Quantity of Wool and Cotton in Mixed Textures.—It is often desirable for manufacturers to ascertain simply and quickly the number and position of cotton threads in a texture containing wool and cotton, and the respective quantities of wool and cotton in mixed yarn. Hafmann has observed that a solution of fuchsine, boiled with an alkaline lye, gives a colourless liquor which contains rosaniline. If from this liquor is separated by the filter a flaky precipitate, which is formed when a woollen and cotton texture or mixed yarn is plunged into the liquor as hot as possible, it becomes after a few minutes quite colourless. If the specimen is then put into a vessel full of cold water, or carefully washed, the red colouring of the wool appears as soon as the alkali has been removed by washing, but the cotton does not take the least colour.

After the mixed texture is dried, every thread may at once be easily counted and distinguished in mixed yarn with a thread-counter. As articles are dyed to a higher degree of intensity with fuchsine, this method is equally applicable to coloured yarns.

The colourless solution of rosaniline is easy to prepare by boiling and dissolving a few grammes of fuchsine in 30 cubic centimetres of water, and while the liquor boils, adding to it, drop by drop, potash or soda lye till there is discoloration. The filtered solution keeps in a stoppered bottle as long as is desired. Before use again, it need only be warmed, though that is not indispensable. It is scarcely necessary to point out that silk behaves like wool, and flax or other vegetable threads like cotton.

M. E. Liebermann in *Le Moniteur de la Teinture, Oct. 20, 1876.*

Insurance against Loss of Employment through Fire.—The *Société Industrielle de Reims* considering the loss of employment often caused by fire, have passed a resolution recommending the insertion of a special article in fire insurance policies to insure the amount of wages paid to workpeople, for a week or a fortnight, by paying a premium equitably calculated on the average of premiums paid for insurance, and stipulating that this sum be paid to the insurer on the regular attestation of the fire. Insurance companies have every inducement to adopt this proposal, as it would increase the amount of insured capital without increasing the risks. It would also be a boon to work people in saving them from the distress caused by loss of employment through fire.

Abridged from the *Revue Industrielle, Jan. 23, 1877.*

New Printing Ink easily Removable from Paper.—Printing paper, thrown aside, and put into the stamper to be again made into paper, has the great disadvantage of producing a grey and dirty paste. Printing ink, composed usually of soot and oil varnish, is very difficult, if not impossible, to separate from printed paper, which renders it unsuitable for the manufacture of new white paper. Messrs. Kircher & Ebner have consequently taken a patent for a new black ink, which can be easily removed from printed paper.

To compose it, iron is first dissolved in sulphuric, hydrochloric, or acetic acid. This solution is then mixed by halves with acetic acid, and protoxide of iron precipitated by an alkali, such as soda, potash, &c. Whatever may be the precipitating agent employed, it is sufficient for it to form a soluble compound with the acid in which the iron is dissolved.

The precipitated protoxide of iron is collected and washed, and then treated with a mixture in equal parts of tannic and gallic acid. A beautiful blue-black or pure black ink is thus obtained. This gallo-tannate of protoxide of iron is collected, washed, dried, and immediately mixed with linseed oil varnish. It is then fit for printing.

The complete whitening of the printed paper is effected by dipping it in a bath of tepid water, to which is added ten per of soda or caustic potash. It is left to digest for twenty-four hours, and the whole is put into a stamper to be beaten fine. The paste is then thrown on to a cloth and drained. It is afterwards washed in pure water, to which is added ten per cent. of hydrochloric, oxalic, or tartaric acid. It is left to digest for twenty-four hours, and the paste is then fit for all the processes of ordinary paper manufacture.—*Polytechnisches Notizblatt.*

Removing Grease from Woollen and Cotton Refuse.—There are various methods of restoring woollen and cotton refuse to a fitness for use, but all of them act injuriously on organic matter. A patent has been taken out in Germany for a method by which this disadvantage is avoided. Neither acids nor alkaline substances are used, but simply sulphate of lime (plaster of Paris). For a kilogramme (220 lbs.) of refuse, the same quantity of plaster is taken very dry and powdered, and the whole is mixed in a cylinder well closed. The mixture is left till the greasy materials have penetrated into the plaster which absorbs them with great facility. Then the mixture is put into another cylinder with openings in it, through which most of the plaster will escape. Lastly, the refuse is spread out on hurdles, and what remains of the plaster is separated by heating. By this treatment the refuse recovers all its properties, and is not at all injured.—*Moniteur de la Tinture.*

Manufacture of Wires Covered with Vulcanised India Rubber.—M. H. Menier's process of this manufacture consists in hardening by cold the coating of india-rubber which surrounds telegraphic wires employed for underground communications. The wire is cooled on leaving the machine, and by this means it is rendered sufficiently hard and resisting to pass, without losing shape, on to the winch cylinders which serve to pass it into the machines that cover it with india-rubber. Immediately covered with india-rubber, the wire passes into a vat or tube containing a cold liquid (glycerine, a mixture of chloride of calcium, and water), where it is hardened before passing on to the winch. The wire is wound off thence into a coiler, amidst powdered talc or some

other pulverised substance, which supports it over a large surface, or liquid in which it remains suspended, in order that the weight of the upper spirals may not put those below out of shape. The wire is then vulcanised by ordinary methods. It is better suspended in a liquid.—*Moniteur Industriel Belge, Jan. 1, 1877.*

Colouring Ceramic Paste.—M. Avril colours ceramic paste by means of iron solutions, particularly chlorides, perchlorides, and sulphates of iron. These solutions are applied to ceramic paste in the body of the paste, by soaking and kneading the earth in contact with these solutions, or on the surface, by soaking the products, burnt or biscuit baked, in a solution of the salts of iron.

The process may be applied to the dry or the wet state, with hot or cold solutions. The proportions vary according to the colour which is to be produced.

This invention is applicable to colouring bricks, tiles, slabs, the pottery of buildings, and the decoration of objects of art in earthenware. All shades may be obtained, from rose and pale yellow to bright red and deep brown.—*Ibid.*

Tempering Small Steel Articles with Whale Oil.—By melting together 4 or 5 litres (7 to 9 pints) of whale oil, 2 lbs. of tallow, and a quarter of a pound of wax, a mass is obtained which is very suitable for tempering small steel articles of all kinds. By the addition of about a pound of resin the mixture may serve for tempering larger articles. The addition should be made with care, for an excess of this substance makes the steel too brittle. After several months' use the mass loses its power. It must then be completely changed, care being taken to clean the bottom of the vat containing it.

Another mixture, which has been found equally effectual in practice, is composed of 90 litres (20 gallons) of spermaceti oil, 20 lbs. of tallow, 4½ litres (about a gallon) of neat's-foot oil, a pound of pitch, and 3 lbs. of resin. The pitch and resin are melted together, the three other substances are then added one after the other, and the whole is boiled in an iron cauldron till all the water is evaporated. This is ascertained to have taken place when the liquid mass takes fire on contact with a lighted chip. The fire is extinguished by hermetically closing the cauldron with a lid.

The tempering in the two cases is performed as follows :—

The blades of saws, for example, are heated in special ovens, and when they have reached the proper temperature, they are thrust into the tempering mass in tubs arranged side by side. For continuous work a certain number of vats are used, so that the mass has time to cool in proportion as the work goes on. As soon as a blade is suitably cooled, it is taken out of the bath and cleaned with a piece of leather, so that there still remains a thin layer of grease. It is then placed on a coke-fire until the grease catches fire and burns with a clear smoke. In this way the blade acquires suitable elasticity. If it is wanted to be very hard, only part of the grease that covers it is burnt. The softer it is to be, the more complete should be the burning. For springs the flame is left to go out of itself. If the articles have variable forms and dimensions, the burning is repeated at particular parts till all are equally tempered.

Blades may be restored by hammering them, and heating them over a clear coke fire till a straw-coloured tint appears. The colour is removed by washing in diluted hydrochloric acid, and afterwards in water.—*Ibid.*

A Process for Preventing Aniline Blacks from turning Green.—Messrs. Kœchlin Brothers communicated to the *Société Industrielle de Mulhouse* the following note on a process for preventing aniline blacks from turning green :—Aniline blacks subjected to acid reducing agents, such as sulphurous acid or sulphuretted hydrogen (whether in solution or in the gaseous state), assume a greenish tinge, owing chiefly to their more or less complete change to emeraldine, which being a deep blue in the alkaline state, becomes green with the smallest traces of acid.

There is a product more oxydised than aniline black, which is not changed to emeraldine by reducing alkalines or acids, and which is obtained as follows :—Aniline black printed and fixed is finished as usual, then subjected in a vat to an acid oxydation at a tempetature above 167° Fah. Nothing more remains than soaping or simply washing the pieces. Among the oxydators which give the best results may be mentioned the salts of peroxide of iron, chromic acid, and certain chlorates easily decomposed, as chlorate of alumina, &c.

The ferric solution is prepared with a salt of iron at the highest degree, to which is added the same weight, or half as much again, of sulphuric acid at 66°, to prevent the oxide of iron from fixing on the texture. This solution is employed in the ratio of 1 or 2 grammes (15½ or 31 grains) per litre (a pint and three quarters), 1 to 2 litres (1¾ to 3½ pints) being used per dyeing vat for six or eight pieces, which are there treated for half-an-hour to an hour at 176° Fah.

Terric salts being less common in commerce than ferrous salts, a solution may be prepared as follows :—20 kilogrammes (44 lbs.) of ferrous sulphate or copperas dissolved in 60 to 70 litres (13 to 15½ gallons) of water, to which are added 5 kilogrammes (11 lbs.) of bichromate of potass, and 15 to 18 litres (3¼ to 4 gallons) of sulphuric acid at 66°.

It is necessary to use the above proportion of water, on account of the heating of the liquor by the sulphuric acid, and the difficulty of dissolving the copperas. From 4 to 8 litres (7 to 14 pints) of this liquor are taken, and the same process as above is adopted.

For the black and orange kinds chromic acid is used in the ratio of 300 to 400 grammes (4½ to 6 oz.) per vat for six to eight pieces (say 4½ to 6 oz. of bichromate, and nearly half a pint of sulphuric acid), working in other respects as with the iron. It will be necessary afterwards to change to orange in alkaline chromate.

For the black and fast blue kinds it will be necessary to leave a slight excess of copperas in the liquor, as chromic acid would destroy the blue. Therefore 4 kilogrammes (8¾ lbs.) instead of 5 (11 lbs.) should be taken for the above compound.—*Bulletin de la Société Industrielle de Mulhouse, December, 1876.*

The Purification of Fuchsine and Azaleine.—A process for purifying fuchsine, which, with some modifications, is applicable to azaleine also, is described in the *Bulletin de la Société de Mulhouse*, by M. E. Hofer, Grosjean. Besides giving very beautiful and regular tints, it has the further advantage of making them of any intensity both on wool and cotton. The fuchsine is exhausted by boiling water, more or less of which is required, according to the preparation of the product. The liquors are filtered through linen, and collected, and, while they are still lukewarm, ammoniac is added, about 200 grammes (7 oz.) per kilogramme (2¼ lbs). The proportion varies a little according to the product, but excess must be avoided. If too little is put, there is a loss of colouring matter.

The precipitate, which is sometimes powdery, sometimes resinous, is collected on a filter after the clear liquid of a yellowish rose colour floating on the surface is poured off. The precipitate is dissolved in alcohol by using a litre (1¾ pint) per kilogramme (2¼ lbs.) The alcoholic solution is filtered, and, added to the water of gum arabic or gum tragacanth, it gives the colour for wool. For cotton it is sufficient to put in a solution of albumen also. If to the alcoholic solution several times its volume of boiling water is added and left to cool, a little tarry matter is precipitated, carrying colouring matter with it. After having filtered, you get a bath which gives clearer and more diluted colours than those described above. This bath dyes silk, wool, and cotton treated with albumen very well without the addition of any kind of alkali, and gives very clear tints. By evaporating the alcoholic extract a beautiful colour for water-colour painting may be obtained.

To purify azaleine, take a kilogramme (2¼ lbs.) of azaleine, and mix it with 3½ kilogrammes (7¾ lbs.) of dry sand, previously washed with water and sulphuric acid, and afterwards with pure water. The azaleine fastens on the sand and is then easily exhausted. Two litres (3½ pints) of water, and 50 grammes (1¾ oz.) of ammoniac are added. The object of this operation is to rid the azaleine of part of the tar and an acid yellow substance. Then 5 litres (8¾ pints) of boiling water and 200 grammes (7 oz.) of acetic acid at 8 deg. are added. The liquid is filtered through linen, and the residue is completely exhausted by boiling water. About 30 litres (6½ galls.) of liquid are obtained, to which are added 200 grammes (7 oz.) of ammoniac. The treatment is continued for fuchsine by dissolving the precipitate in a litre (1¾ pint) of alcohol. The alcoholic solution is used like that of fuchsine. It gives tints as clear as that, but more violet-coloured.

Properties of Dynamite.—The following experiments were lately made at a dynamite factory, near Lauenberg, in the presence of a number of scientific men :—

1. A keg with about 5 lbs. of dynamite (the contents of which were previously proved to be dynamite) was repeatedly let fall on a stone pavement from a height of 20 feet. It fell open without exploding. Nor did it explode though it was several times thrown with violence on to the pavement.

2. A weight of about 20 lbs. was let fall from a height of 20 feet on to a cartridge with dynamite resting on a stone. The

cartridge was beaten completely flat without exploding. The contents of the cartridge were proved to be dynamite, as a plank was shattered to pieces by the lighted cartridge.

3. A keg with 15 lbs. of dynamite, previously tested, was kindled by a burning cigar, and the contents burnt without explosion, and without injury to the keg.

4. A closed keg, with 25 lbs. of dynamite, was burnt in an open fire. It burnt without explosion, and without danger to those standing at some distance off.

5. A sheet iron box, with about 4 lbs. of dynamite and a cover fastened on, was thrown into a fire, and the contents burnt without explosion, and with only a slight puffing.

6. A similar box, with 5 lbs. of dynamite, was lighted without percussion cap, only by means of a quick-match, and the contents burnt without explosion.

7. An ordinary and a priming cartridge, each containing 60 grammes (about 2 oz.) of dynamite, were laid free on a plank rather more than three inches thick and made to explode. The plank was soon completely broken through. A similar quantity of dynamite in a simple cartridge was laid under a plank 4 inches thick and exploded. The plank was thrown in splinters in all directions.

8. A beam, 9 inches in diameter and 3¼ ft. long, was completely torn asunder by a pound of dynamite laid upon it. The interior was quite crumbled.

9. A wrought iron plate, three-quarters of an inch thick, 7¾ inches square, laid upon soft ground, was bent through and cracked by the explosion of 3½ oz. of dynamite, which was previously covered with earth. A similar plate, resting on stone, was also much torn, and the stone underneath broken, by 3½ oz. of dynamite.

10. A wrought iron cylinder, the walls of which were more than an inch and a half thick, the hollow three-quarters of an inch in diameter, and the length 10½ inches, was buried about six inches in the earth, and covered up. By two cartridges containing together 3½ oz. of dynamite it was torn into several pieces along its length.

11. A large granite stone, more than a yard long, 3½ inches broad, and 19½ inches thick, was completely shattered and partly strewn about by a cartridge containing about half-an-ounce of dynamite in a bore-hole of about 8 inches.

12. To show the explosion of dynamite under water, an ordinary fossil meal cartridge, containing 8¼ oz., was exploded, and the water raised to a height of about 100 feet.

13. Seven stakes were rammed into water, with half-a-pound of dynamite by the side of each—five stakes 3¼ ft. from each other, one 6½ ft. off, and another 9¾ ft. All the stakes were thrown out and broken to pieces by lighting a single one of the cartridges.—*Gewerbeblatt für Würtemberg.*

Practical Literature.

COLONIAL ENGINEERING.*

MR. DOBSON'S book is "not written for engineering students so much as for those who have attained proficiency in one or more branches .... and who on accepting Colonial employment find themselves engaged on work outside the range of their professional training or experience." It is therefore useful to those of our readers who, whether students at the Crystal Palace School or in private establishments, have to start in life at the Cape of Good Hope, India, Australia, or in America. There are fifteen chapters treating on Survey work, Levelling, Setting out of Circular Curves, Selection of Road Lines, Storage of Water, Carpentry, Tunnelling, and the correlatives.

The young engineer must make a rough survey, which, as a preliminary, can be done best with the eye and ordinary observation. If he wants the spirit-level or the odolite, he will thereby learn where and how to use them in connection with the ordinary tables which are herein given; but when he turns to river-crossing he will find some practical advice which, in the absence of previous knowledge, will be most useful. Hills, valleys, levels, and water-courses in a new colony assert themselves in a way that requires the engineering faculty to overcome; and in such work the minute directions supplied by Mr. Dobson will at least be of considerable utility where fords and mountains have to be encountered and overcome. So is it with mountain passes and the choice of road lines: the level is the instrument, but the method of utilization is sometimes tormenting. The young engineer would do well to have this manual by his side—not exactly to follow as a guide, but as a friend and suggester.

In the treatment of necessary roads our methods are of little avail, and the result of Colonial experience described by Mr. Dobson may serve to supplement the conclusions, or rather half-conclusions of the engineers, by pointing out the way he has found in the arduous matter of overcoming difficulties imposed by nature. So is it with the treatment of water, which interferes most desperately with road-making here in England, and especially in rough lands not yet reduced by geological survey in a physical sense.

When the subject of selecting and constructing railway lines forms part of the civilising process, the advice concerning road-lines becomes of more potent interest; and the failure, in matters of detail, of the utmost gravity in importance. Here Mr. Dobson prescribes instructions that should not be disregarded. The lines must be short, and as railway surfaces are artificial, they must be partly natural and partly constructed; sharp curves and steep gradients are to be avoided, because of their primary cost, and because of the rolling stock expense; stations should be most carefully selected, especially when the ordinary roads have to be made at the same time as the feeders. Then follows miscellaneous directions, obvious or otherwise, depending on the case in hand, which looks only to the probable results.

On the Storage of Water—ever necessary in a new country, because the natural drainage is not only prompt, but, if obstructed, violent, especially when by colonization the turf is hardened by the tramping of cattle, &c.—the construction of dams is of the utmost importance; whether or not they are of earth, and if so, of what strength, and whether to be puddled or not. These matters have especial interest where, by reason of town-creation, it becomes desirable to employ masonry, for by them is a reservoir made to treasure a week's, a month's, or a three months' supply, according to the impetus of the stream, the area of the valley, and the possible requirements of the collected houses or farms. Levels have to be considered likewise; for if—as we have seen in England—towns grow faster than the provision made for them can meet, there may happen a catastrophe like as at Holmfirth; and an engineer needs to be far-seeing and very firm in his responsible care for due provision and prevention. Then where the probability or possibility of townships springing as from the soil arises, there comes another question—that of town sewage; and it must be regarded by the engineer, for, if neglected, all his careful prevision and provision in regard of water and roads comes to an end by the advent of malaria and the consequent generation of diseases.

Finally, in the Selection and Location of Town Sites themselves—which are not of the engineer's choice, but which often interfere with his personal observation—the counsel offered is useful. The considerations leading to the creation of a town are nothing to him. Trade must be prepared for—landing-places, fords, and the confluence of rivers make all towns. He has to govern the line of streets in a way that shall conduce to the idea of the colony expressed through the Government; and it is in this particular he makes his mark of honour or his mark of failure. Towns have often been made by the sheer wilfulness of the squatters, against the opinion of wise, far-seeing men, and the town comes to grief. That occurred in New Zealand, where hotels, warehouses, &c., were put up to lead to a bog, which in dry weather killed every soul that could die; or, in other words, the people were under water. Spontaneous settlements seldom turn out well: the engineer must acquire local confidence, and save the places from being used, or, if construction is inevitable, from being ruined. In all cases the engineer, who really becomes an architect, should make his street lines and the widths of them sufficient for a much greater traffic than is at present required; so will he best benefit those who have trusted him, but by such means will he crown himself with substantial honour. The choice of locality as to gas and water-works is left to the inhabitants: they are not likely to blame if they have been duly made acquainted with the opinions of the engineer.

The author discourses on Carpentry, and in detail shows the peculiarities of hard and soft wood in matters of construction, and also of pile-driving, recognising, moreover, the employment of bolts, straps, beams, and girders. Then follow chapters on pile-driving, tunnelling of rocks, &c.; and, lastly, sundry clerk orders on general business. The volume is most useful to a colonist, and especially so to a Colonial engineer.

* *Pioneer Engineering: a Treatise on the Engineering Operations connected with the Settlement of Waste Lands in New Countries.* With Plates and numerous Woodcuts. By Edward Dobson, Associate of the Institute of Civil Engineers, and author of the Railways of Belgium, &c. London: Crosby, Lockwood, & Co. 1877.